## ABOUT THIS BOOK

Scientific Physics is physics based upon ordinary empirical scientific principles. Traditional orthodox physics has become mired down in mystical ideas, antiscientific principles, and denials of obvious experimental facts.

The evidence reviewed in this book proves space-time is absolute - no "special relativity" nonsense.

A cosmology is presented for an eternal, infinite, uniform in-the-large, steady-state, nonexpanding universe that fits all of the facts - no impossible "big bang", no "curved space", no expanding universe", no "bounded universe", etc.

The far reaching consequences of mass-energy equivalence (known in the 1800's) are explored, yielding neomechanics in absolute space-time, a new gravitational theory, etc.

An electrodynamic field theory is presented that agrees with Ampere's original force law, with Weber electrodynamics for slowly varying effects, and predicts longitudinal electrodynamic $\vec{E}$ waves (recently observed), yields the force that drives the Marinov motor and that explains the Aharonov-Bohm effect - no error ridden Maxwell theory, no Faraday law of electromagnetic induction, no absurd Biot-Savart law, etc.

The conditions for creating thermodynamic order are presented, which indicate why low entropy life exists, why stars are born from high entropy gas and dust, why territorial behavior of all organisms and man, etc.

It is shown how quantum particles move along discrete trajectories as explicit function of time to yield all observed wave behavior. The empirically correct Wesley wave, $\Psi = \sin[p\cdot(r - vt)/K]$, for free particles is generalized to yield wave equations for bound particles - no "wave-particle duality", no single particle interfering with itself, no single particle going through both slits to produce interference, no "uncertainty principle", no intrinsic "probability amplitudes", no superposition of physical states, no "complementarity", no astrological "nonlocality", no thoughts affecting experimental results, no "indistinguishable" particles, no "expectation values" as observables, no "operator approach", no etc.

ISBN 3-9800942-9-4

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# SCIENTIFIC PHYSICS

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# SCIENTIFIC PHYSICS

by

JAMES PAUL WESLEY, Ph.D.

2002

**Benjamin Wesley - Publisher**

Weiherdammstrasse 24

78176 Blumberg, Germany

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This book is dedicated to

**Physicists Interested in Science**

rather than in mere traditional orthodoxy.

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ISBN 3-9800942-9-4

QC171

# PREFACE

This book is written in the hope that it may help to return a little *science* back into *physics*. It is written for physicists, who are interested in *science* as well as *physics*.

It seems to be generally recognized that present-day *physics* has lost its empirical basis. It is no longer the pure exact empirical *science* that it is supposed to be. Physics has become a morass of mystical ideas, nonsense, antiscientific principles, and denials of obvious experimental facts.

Physics is now big business, involving high status, prestige, and lots of money. It has become too "important" to be guided by mere scientific curiosity. Big money, big government, big societies, big universities, big research institutions, and big physics journals have too much vested interest in standard orthodox physics to hazard anything new. The *safe* old traditional beliefs, right or wrong, silly or serious, must be preserved and perpetuated. Progress stagnates.

Old orthodox errors, some of them centuries old, along with some newer orthodox errors continue to accumulate. Some of these orthodox errors and absurdities are revealed and discussed here. Corrections are presented; and some new alternative *scientific physics* is offered.

Only a few selected topics can be treated in this small volume. Much more *scientific physics* research needs to be undertaken.

The author acknowledges and appreciates the many valuable and crucial scientific experimental results and ideas provided by numerous physicists actively engaged in scientific physics research, whose contributions have been generally suppressed or ignored in the orthodox physics literature, such men as Stefan Marinov, Francisco Müller, Thomas Phipps, V. F. Mikhailov, Panos Pappas, Andrē Assis, Peter Marquardt, Christian Monstein, George Galeczki, E. K. Conklin, Dontsov and Bas, Peter Graneau, and M. Hoek.

The author is especially indebted to those who helped in the preparation of this volume by offering valuable suggestions, correcting errors and doing proof reading, such as Peter Marquardt, Dieter Braun, and Thomas Phipps.

J. Paul Wesley
2002



# INTRODUCTION

The evidence presented in Chapter 1 for *absolute space-time* is overwhelming and conclusive. "Length contractions" and "time dilations", that depend upon the subjective point-of-view of an observer moving with some arbitrary *relative* velocity, are rejected. There can be no non-simultaneous "simultaneities". The observed oneway velocity of energy propagation of light $c^*$ is a function of the absolute velocity of the observer $v$, such that $c^* = c - v$, where $c$ is the oneway velocity of light relative to absolute space.

*Mass-energy equivalence*, $E = c^2 m$, deduced from the electrodynamics of the 1800's and subsequently experimentally confirmed, is an important priniciple with far-reaching consequences: The mass equivalent of kinetic energy yields mass change with velocity such that $m' = m\gamma = m/\sqrt{1 - v^2/c^2}$ (as experimentally confirmed by Kaufmann in 1901), which, in turn, leads to neomechanics in absolute space-time. The inertial mass equivalent of electrostatic energy can be used to derive Weber's all-important velocity potential. It can also be used to derive the altered inertial mass of electrons moving in a uniform electrostatic potential field, as observed by Mikhailov. The gravitational mass equivalent of photon energy can be used to derive the observed gravitational red shift (Pound and Rebka). The negative mass equivalent of the nucleon-nucleon binding energy can be used to determine nuclear masses (Green and Wesley). The mass equivalent of the gravitational field energy can be used to obtain Wesley gravitation, as discussed in Chapter 3. The mass equivalent of the gravitational potential energy due to the distant masses in the universe (as derived from the Weber theory applied to gravitation) yields the gravitational potential due to the distant masses as $\Phi = c^2$.

A cosmology based upon an eternal, infinite, steady-state, uniform in-the-large, nonexpanding universe fits observations the best, using only the empirically established laws of physics. Far-fetched speculation about a "big bang", an "expanding universe",

"curved space", or a "bounded universe" generate numerous unresolvable problems and unanswerable questions without providing any answers.

A gravitational drag is proposed that acts on photons travelling through space produced by a gravitational red shift, which: 1) is responsible for the cosmological red shift, 2) resolves Olbers' paradox, 3) removes the light energy without over-heating any intergalactic matter, 4) rejuvenates the universe by converting high entropy thermal energy of low utility into gravitational potential energy of maximum unit utility (by the local expansion of matter in the wake of the photons), 5) yields the observed temperature of about 2.7°K for the cosmic background as the cosmological red shifted "tired light" remnant of the light from distant galaxies, 6) provides a mean free path for photons of about $10^{10}$ light years to lose half their energy, 7) provides a measure of the time necessary for thermal equilibrium to become established in the universe of more than $10^{10}$ years, 8) and indicates that fluctuations lasting $10^{10}$ years make a "heat death" impossible in the steady-state universe. From gravitational mass equivalent of neutrino energy, neutrinos are subject to the same gravitational drag as photons, which can then account for the recycling of neutrino energy in the steady-state universe.

Introducing the mass equivalent of the gravitational field energy as part of the source mass for the gravitational field, the Wesley gravitational force is found to decrease a little more rapidly with distance than the inverse square law. In a universe of uniform mass density $\rho_o$ it yields an exponentially decreasing gravitational potential with distance with a cosmological constant equal to $\sqrt{4\pi G\rho_o}/c \sim 10^{-11}$ per light year, which resolves Seeliger's paradox. The gravitational potential at a point in a universe of uniform mass density is $\Phi_o = c^2$, in agreement with the Weber theory for gravitation.

Wesley electrodynamic field theory is a generalization from Weber electrodynamics to include the effect of absolute space, which allows for radiation, lacking in the Weber theory. The Wesley theory is based upon the causes, as given by moving charges and two fundamental potential fields that they produce, defined by $\Lambda = \int \rho R$ and $\mathbf{N} = \int \mathbf{J} R$. The more familar potentials are then $\Phi = \nabla^2 \Lambda /2$ and $\mathbf{A} = \nabla^2 \mathbf{N}/2$, as assumed by the Maxwell theory. The Maxwell theory is severely limited and fails many important experimental tests. Being limited to macroscopic mechanically rigid closed current loop sources, it cannot yield the force on Ampere's bridge, nor any results involving open circuits (such as the fields produced by an electric dipole antenna), nor the forces and fields involving only individual moving point charges. Pure transverse electrodynamic waves involving only an $\mathbf{A}$ field are predicted. In general, where both $\Phi$ and $\mathbf{A}$ are involved, the radiation field has both transverse and longitudinal properties. Pure longitudinal $\mathbf{E}$ waves (scalar $\Phi$ waves) are predicted and have been observed by Monstein.



All of the many situations involving induction may be explained by the force of induction $\mathbf{F}$ on a charge q due to other accelerating, or apparently accelerating, source charges given by $\mathbf{F} = -q d\mathbf{A}/dtc$, where the total time derivative for a point moving with the velocity $\mathbf{v}$ in the vector field $\mathbf{A}$ is given by the proved theorem $d\mathbf{A}/dt = \partial \mathbf{A}/\partial t + (\mathbf{v} \cdot \nabla)\mathbf{A} + (\mathbf{A} \cdot \nabla)\mathbf{v}$. The last term has been previously overlooked; but it is necessary for some cases of induction. The Faraday law of electromagnetic induction, where a changing magnetic $\mathbf{B}$ flux is supposed to cause induction, is wrong; the force driving the electrons in the wire causing the emf (where the $\mathbf{B}$ field is zero) is given by the $\partial \mathbf{A}/\partial t$ term. In addition, the seat of the emf is localized (as proved by F. Müller) and is *not* produced uniformly around a current loop as required by the Faraday law. The motional induction governed by the $(\mathbf{v} \cdot \nabla)\mathbf{A}$ term yields the torque driving the Marinov motor; and it produces the forces that yield the Aharonov-Bohm effect (no spooky quantum mechanics is involved).

A statistical thermodynamic system can reduce its own entropy and increase its thermodynamic order if it has a source of low entropy energy, such as sunlight that it can convert to high entropy thermal energy, that can then be radiated off into deep space as waste entropy. A system to proceed toward states of lower entropy must, thus, produce much more entropy external to the system itself. *Entropy production*, thus, drives a system toward greater thermodynamic order. It allows low entropy stars to evolve from high

entropy gas and dust. It permits the existence of low entropy life in a high entropy environment. "Ecophysics" is the study of ecology involving the *physical* needs for life. Life evolves to utilize more of the available solar energy; so the biomass of the biosphere increases over geologic time; and the ecological efficiency (the energy dissipated to the ordered biomass sustained) increases over geologic time, thereby producing larger individual organisms and a proliferation of species. Territoriality involves the struggle to gain and maintain a sufficiently large territory supplied with sufficient sunlight to survive. Wars are a product of man's territorial drive.

The social forces fostering science or against science are very strong and complicated. It is difficult to say whether or not *scientific physics* has a future (?).

The most serious problems, absurdities, and nonsense in the present-day generally accepted orthodox Copenhagen quantum mechanics can be traced back 200 years to the false naive interpretation of Young's double pinhole interference experiment. The *superposition principle* was falsely and naively interpreted as a causal principle. In particular, the wave amplitudes $\Psi_1$ and $\Psi_2$, supposedly travelling from each of the two pinholes, were supposed to arrive at a point on the screen where they added together to *cause* the resultant intensity observed. But a wave amplitude $\Psi$, alone does not represent the essential physical properties of a wave. The essential physical property of a wave, that is observed and that *necessarily* prescribes *physical causality* is the *energy flux* defined by $S = -\nabla\Psi\,\partial\Psi/\partial t$ (for scalar waves). Since the time-average flux is divergenceless, $\nabla \cdot \langle S \rangle = 0$; the lines of wave energy flow cannot cross each other. It is, thus, obvious that nothing *physical* can proceed from each of the two pinholes to arrive at a point on the screen to *cause* the resultant intensity. By examining Fig. 11.2, displaying the energy flow lines, it is seen that *all* of the energy from the upper pinhole ends up on the upper half of the screen. The flow is diverted by the flux from the other pinhole. In addition, there is a transverse standing wave pattern involving no energy transfer, that guides the energy flow along paths forming the observed pattern on the screen. When two wave amplitudes are mathematically superposed, it does



not mean that the resultant amplitude, $\Psi = \Psi_1 + \Psi_2$, represents a physical state that is a combination of a $\Psi_1$ physical state plus a $\Psi_2$ physical state - anymore than the number 5 is a physical combination of a 2 and a 3 - or each term of a Fourier series represent simultaneously existing physical states. Superposition is *mathematics* and not *physics*.

It was generally believed in the early 1800's, without proper justification, that Young's double pinhole interference experiment proved that light could not be a flux of Newton's photons; and it had to be a wave in a luminiferous ether, as is still taught in physics textbooks today. But even then, there were protests that light could not cross the absolute zero nodal surfaces separating one pinhole from the other. Recognizing the energy flux S as the physical reality, a flux of particles travelling along the same lines as S will yield *all* possible wave results. Whether a wave is a propagated property in a continuous material medium, such as a sound wave, or is a flux of quantum particles cannot be determined by wave behavior alone. Since there is no otherwise detectable luminiferous ether; light must be a flux of photons.

The wave-particle problem could have been, and should have been, resolved 200 years ago. The author presented the resolution many years ago. But orthodoxy still refuses to recognize the necessary resolution. Ignorance is preferred to any break with tradition.

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CHAPTER 1

# EVIDENCE FOR ABSOLUTE SPACE

One of the most serious and perplexing problems in physics is the choice of the appropriate frame of reference to define positions, velocities, and accelerations of bodies and particles that can then be used in fundamental physical laws (Wesley 1998). The immediate practical frame of reference is the laboratory frame, which is adequate for most practical everyday purposes. But if the laboratory itself is moving and if precise results are desired, the laboratory frame may no longer be sufficient. In particular, the basic problem is: How should kinematics be specified in order to yield valid predictions?

## 1.1 Geometry

It is necessary to make a distinction between "physical geometry" and "mathematical geometry". "Physical geometry" involves the laws and rules embodied in Euclide's axioms in three dimensional space that are verifiable by actual observations. Time is not involved. Cause-and-effect is not involved. Observations can be repeated indefinitely on precisely the same setup to yield precisely the same results.

"Mathematical geometries", on-the-other-hand, may involve the introduction by postulation of arbitrary nonverifiable, or fantasy parameters, elements, or rules, such as "space curvature", more than 3 space dimensions, and a time dependence. Such "mathematical geometries" are generally supposed to reduce to "physical geometry" for special choices of the arbitrary parameters, elements, or rules: when the "space is flat", when only 3 space dimensions are involved, or when time intervals go to zero.

"Mathematical geometries" are of no interest in this book, which is concerned with *physics* and not with *mathematics* per se. Thus, the "four space-time covariant formalism" of "special relativity", which mixes time with the 3 space dimensions, is neglected. In addition, it is important to note that "special relativity" has no basis in experimental nor empirical fact, despite frequent fanatical claims to the contrary. For example, all three of its fundamental postulates or axioms, 1) relativity, 2) constancy of the velocity of light, and 3) covariance, contradict well established empirical evidence. 1) Relativity denies the existence of a unique preferred stationary frame of reference, or "absolute space", which is known to exist (as discussed in detail in this Chapter). 2) The observed oneway velocity of light $c^*$ is not independent of the absolute velocity of the observer $v$; it is $c^* = c - v$ (as discussed in detail in this Chapter). And 3) covariance is violated; because the laws of physics are not of the same form in all inertial (nonaccelerating) frames; they take on a unique form in the preferred rest frame (as shown below in this Chapter). Moreover, the obvious contradictions, or paradoxes, of "special relativity" make it *mathematically absurd* (Galeczki and Marquardt 1997). For example, twins returning from fast round trips are supposed to find each younger than the other!

The "curved space" of "general relativity", depending upon the distribution of matter, has no laboratory nor empirical basis. "Physical geometry", being based upon actual observations only, does not admit any such mathematical extrapolation, speculation, or fantasy. (A *necessary* gravitational theory compatible with "physical geometry" and with empirically established laws, that is able to provide more answers, is presented below in Chapter 3.)

## 1.2 Kinematics

The "physical kinematics" considered here involves the position, velocity, and acceleration of objects, matter, or energy, that can produce irreversible effects. Pure "mathematical kinematics", involving the motion of an arbitrary mathematical point, where there is no accompanying physical transport of matter or energy, is



not considered: For example, the point that a search light illuminates clouds can have a very large velocity and acceleration, as the search light is swung back and forth. The motion of the point of illumination represents pure mathematical kinematics; because no matter nor energy is transported in the direction of the illuminated point. Here only pure physical kinematics, involving the motion of an object, matter, or energy is associated with the words "point", "velocity" and "acceleration".

A reference frame can be defined by a collection of *fixed* objects distributed in three dimensional space. A fixed origin and three mutually perpendicular cartesian directions can then define a cartesian frame with reference to the fixed objects. The position of any body or particle can be specified by its position vector given by

$$\mathbf{r} = x\mathbf{e}_x + y\mathbf{e}_y + z\mathbf{e}_z, \tag{1.1}$$

where $x$, $y$, and $z$ are the three coordinate distances from the origin and $\mathbf{e}_x$, $\mathbf{e}_y$, $\mathbf{e}_z$ are unit vectors in the three mutually perpendicular cartesian coordinate directions.

The "velocity" of a body or particle is defined as the distance travelled $\Delta\mathbf{r}$ between the point $\mathbf{r}'$ to $\mathbf{r}$, where

$$\Delta\mathbf{r} = \mathbf{r} - \mathbf{r}' = \Delta x\mathbf{e}_x + \Delta y\mathbf{e}_y + \Delta z\mathbf{e}_z \tag{1.2}$$

in the time interval $\Delta t = t - t'$ between the times $t'$ to $t$; thus,

$$\mathbf{v} = (\mathbf{r} - \mathbf{r}')/(t - t') = \Delta\mathbf{r}/\Delta t. \tag{1.3}$$

An *instantaneous* velocity $\mathbf{v}$ may then be defined as this ratio as $\Delta t \to 0$ and thus $\Delta\mathbf{r} \to 0$, which is the first derivative of the position $\mathbf{r}$ with respect to the time $t$; thus,

$$\mathbf{v} = d\mathbf{r}/dt. \tag{1.4}$$

The "acceleration" of a body or particle is defined as the change in the instantaneous velocity, $\Delta\mathbf{v}$, in the time interval $\Delta t$; thus,

$$\bar{\mathbf{a}} = \Delta\mathbf{v}/\Delta t. \tag{1.5}$$

And the *instantaneous* acceleration is then defined as this ratio

when $\Delta t \to 0$ and thus $\Delta v \to 0$, which is the first derivative of the velocity with respect to the time t and the second derivative of the position with respect to the time t; thus

$$a = dv/dt = d^2r/dt^2. \tag{1.6}$$

The centripetal acceleration associated with rotation has played an important role in the development of kinematics and in physics in general. The acceleration of a body or particle in cylindrical coordinates, r, $\phi$, and z, where

$$\begin{gathered} x = r\cos\phi, \qquad y = r\sin\phi, \qquad z = z, \\ e_x = \cos\phi\, e_r - \sin\phi\, e_\phi, \qquad e_y = \sin\phi\, e_r + \cos\phi\, e_\phi, \end{gathered} \tag{1.7}$$

where $e_r$ and $e_\phi$ are unit vectors in the r and $\phi$ directions, is given by

$$a = (\ddot{r} - r\dot{\phi}^2)e_r + (2r\dot{r}\dot{\phi} + r\ddot{\phi})e_\phi + \ddot{z}e_z, \tag{1.8}$$

where dots over symbols refer to differentiation with respect to the time t. For uniform circular motion, where $\ddot{z} = 0$, $\dot{r} = 0$, $\ddot{r} = 0$, and $\dot{\phi} = \omega$, a constant, the acceleration from Eq.(1.8) becomes

$$a = -r\omega^2 e_r. \tag{1.9}$$

This centripetal acceleration, Eq.(1.9), having been derived from the general expressions (1.6), (1.7) and (1.8), means that linear acceleration and centripetal acceleration are physically identical phenomena.

## 1.3 Choice of the Fixed Frame of Reference

The problem in "physical kinematics", that does not exist for pure "mathematical kinematics", is the selection of the appropriate frame of reference for the fixed cartesian coordinate frame. Conceptually a coordinate frame might be chosen as fixed inside a flying airplane, or on the surface of the rotating Earth, or in principle at the center of the Earth with the celestial sphere taken as stationary, or in principle at the center of the Sun with the celestial sphere taken as stationary, or in principle at the center of mass of the solar system, or in principle at the center of the Milky Way Galaxy, or etc.



1.3a The frame of reference chosen to provide prediction using the laws of mechanics – Since physical kinematics, based upon observations, is to be used in physical laws to provide prediction; it is important to know what frame of reference is appropriate for what physical laws. Probably the most important laws used to predict results are the laws of classical mechanics; so the appropriate fixed frame of reference is that which permits prediction using the laws of classical mechanics.

The laws of classical mechanics were arduously discovered by experiments in laboratories fixed to the Earth's surface by Flemish scientists in the 15 hundreds. Their results may be summarized as Newton's second law,

$$F = ma, \tag{1.10}$$

where F is a force acting on a body of mass m causing it to accelerate with the acceleration a. Before Newton's second law can be applied the all important question that must be answered is: How is the acceleration a to be defined? What is the appropriate reference frame? The walls of the laboratory fixed to the surface of the Earth yielded a satisfactory frame of reference for the early discoverers of Newton's second law.

A philosophical question arises: If a frame of reference is accelerating with respect to the laboratory fixed on the Earth's surface, will Newton's second law still hold in this accelerating frame? Newton's second law will not be valid in this accelerating frame; because, if the frame has the acceleration $a_o$ with respect to the Earth's surface, a body in this system will appear to have the acceleration $(a - a_o)$, where a is the acceleration of the body with respect to the Earth's surface, and Newton's second law would be

$$F = m(a - a_o), \tag{1.11}$$

which predicts a different force than the correct force given by Eq.(1.10). A ball thrown in the air in an accelerating automobile is found to accelerate with respect to the automobile; even though no force is acting on the ball. Newton's second law is not valid for a frame fixed to an accelerating automobile. The fixed frame of

reference *necessary* for Newton's second law to be valid must be chosen as fixed to the surface of the Earth (neglecting, of course, the small accelerating of the Earth's surface for the present illustration).

1.3b The constants of the motion reveal the preferred fixed frame - The force predicted by Newton's second law, Eq.(1.10), is invariant to a constant velocity component of the body's motion; since

$$d\mathbf{v}(\text{constant})/dt = 0. \tag{1.12}$$

This means Newton's second law remains valid in any reference frame moving with a constant velocity relative to the Earth surface (assumed nonaccelerating, as approximately valid, in agreement with the early laboratory investigations). Thus, within a train moving with constant speed along a straight portion of track or in an airplane flying with a constant speed in a straight line Newton's second law is as valid as on the Earth's surface. Within the train or airplane, assumed isolated from the rest of the universe, the behavior of bodies will appear to be as normal as on the Earth's surface.

Unfortunately, unwarranted conclusions have been often drawn from this simple fact. For example, Mach (1933) assumed that it meant that no priviledged frame of reference could possibly exist. All "inertial frames" (frames with zero absolute acceleration) were supposed to be physically equivalent. However, this interpretation, while superficially acceptable for Newton's second law itself, is not acceptable for Newtonian mechanics, which must also involve the constants of the motion, obtained from the integration of Newton's second law. The all important conservation laws for linear momentum, for angular momentum, and for energy involve the constants of the motion. Classical Newtonian mechanics, thus, involves the velocities of bodies and not merely their accelerations.

It is thus not sufficient that the deceptive appearance of normality in trains and airplanes be regarded as something of profound importance. Trains and airplanes cannot be regarded as isolated from the rest of the universe; they are a part of the physical system that includes the Earth's surface as well.



Fundamental laws must be as universally valid as possible; they must be valid in as large a system as possible. The constants of the motion, the velocities of bodies, must be chosen relative to the more universal system fixed to the Earth's surface.

The velocities and kinetic energies assigned to bodies in a frame of reference attached to the interior of a moving train or airplane do not have the same value as the velocities and kinetic energies assigned to the same bodies as measured in the frame of reference attached to the surface of the Earth. Thus, if an "inertial frame" were, in fact, a matter of indifference, a man, who is stationary with respect to the interior of a moving train, should be able to step off of the train while it is still moving without ending up in the hospital.

With the advent of Copernicus' sun-centered universe, Galileo's observation of Jupiter's moons, and Newton's gravitational theory, the fixed frame of reference, originally chosen from laboratory observations as any frame fixed to the surface of the Earth, had to be removed to the center of the Sun with a stationary celestial sphere. Only in this new fixed frame could the laws of classical mechanics be strictly valid. Thus, the laws of classical mechanics originally found to be only valid for the Earth's surface were found to be also valid for the Solar system and apparently for the entire universe.

## 1.4 The Fixed Stars and Absolute Space

The existence of a fixed pattern of stars on the celestial sphere seen in the night sky provides the most obvious compelling evidence for absolute space. The apparent lack of motion of distant stars means that their actual velocities must be *finite* and thus less than some finite *cosmological limit velocity*. If all velocities were admissible, then, there being more velocities toward infinity, the distant stars should appear to be darting around like fire flies and should not appear stationary. Since *all* distant stars appear stationary; the cosmological limit velocity must be measured with respect to a common universal preferred zero velocity frame of reference, or "absolute space".

It is further important to note that the existence of a cosmological limit velocity for stars implies the same limit velocity for all matter. As a consequence the local laws of mechanics must be such that no body can ever exceed the cosmological limit velocity as measured with respect to absolute space or the preferred universal rest frame. Neomechanics (Section 1.10 below), which is appropriate for fast bodies or particles, embodies such a limit velocity. Newton's second law, in lieu of Eq.(1.10), becomes

$$F = d(m\gamma v)/dt, \tag{1.13}$$

where

$$\gamma = 1/\sqrt{1 - v^2/c^2}\ , \tag{1.14}$$

where v is the absolute velocity of the body or particle of mass m and c equals the oneway velocity of light with respect to absolute space, a universal constant. Since infinite forces cannot exist; Eq.(1.13) says that no body nor particle can be accelerated to absolute velocities greater than c. The cosmological limit velocity must thus equal c.

## 1.5 Absolute Acceleration from Newton's Second Law

The inertial force on a body, ma, Eq.(1.10), depends upon the acceleration of the body a. Considering the accuracy of the early observations, the acceleration a that satisfied Newton's second law could be measured with respect to the Earth's surface as the fixed zero accelerating frame. With the advent of Newtonian gravitation it became clear that the zero accelerating frame had to be taken as the sun and the stationary celestial sphere. Generalizing further, it may be assumed that Newton's second law requires *absolute* accelerations to be precisely correct.

In support of this conclusion is the unique character of the inertial force ma itself. Its magnitude depends only upon the properties of the single body itself, its mass m and its acceleration a. It does not depend upon any property of any other particular body in the universe. Nor does it depend upon its relative distance from any other particular body in the universe, such as required for the gravitational force or the electrostatic force. This means



that the inertial force ma must define an acceleration a that is not *relative* to any other body in the universe. The acceleration that is defined by the inertial force is thus necessarily *absolute*. Newton recognized this fact: Noting that water rises toward the outside of a spinning bucket due to the centrifugal force, he asserted that the centripetal acceleration was *absolute* with respect to the fixed stars that define *absolute space*.

The absolute zero acceleration frame must be identical to the absolute zero velocity frame; since the universe can possess only one unique kinematic frame of reference; and since velocity and acceleration need not be independent. For example, a body revolving in a circle with a uniform absolute angular velocity $\omega$ has an absolute centripetal acceleration $a = -\omega^2 r e_r$, from Eq.(1.9), and at the same time an absolute instantaneous linear velocity $v = \omega r e_\phi$. When the body comes to rest in the absolute rest frame, both a and v, that are coupled together, must come to rest simultaneously; so absolute space is the same space for velocities as for accelerations. However, although absolute accelerations can be readily measured using Newton's second law; absolute velocities are generally very difficult to detect and to measure (as discussed below).

## 1.6 Classical Constants of the Motion Reveal Absolute Space

Newton's second law, Eq.(1.10), itself involves only the acceleration and is thus independent of any constant velocity motion. It would thus appear that any frame of reference moving with a constant absolute linear velocity, an "inertial frame", should be satisfactory for Newtonian mechanics. However, integrating Newton's second law, does not yield integrals of the motion that are arbitrary to within a uniform rectilinear velocity. The description of the motion of bodies can require a specification of constant velocities. Momentum and kinetic energy that involve the velocity of bodies can only be conserved if one particular constant velocity reference frame is chosen to describe the motion of all of the interacting bodies in the system of interest.

It makes no difference how large the system might be or how many bodies may be involved, Newtonian mechanics, that involves the constants of the motion as well as Newton's second law, can only be valid for a single reference frame moving with a constant absolute velocity. To describe the entire solar system only *one* frame of reference is allowed. To describe the behavior of the entire Milky Way Galaxy only *one* reference frame moving with constant absolute velocity is permitted. Extrapolating indefinitely, it is clear that only *one* reference frame is allowed to represent the entire universe. This necessarily unique frame of reference that is valid for the whole universe may be chosen as having a zero velocity, thereby defining a unique absolute rest frame or absolute space.

It is clear that classical Newtonian mechanics, that includes the constants of the motion as well as Newton's second law, is strictly universally valid only in absolute space. Conversely, this fact is sufficient to prove that absolute space must, in fact, exist.

## 1.7 Absolute Space Determined from the Anisotropy of the Observed Oneway Velocity of Light c*

A number of crucial experimental observations reveal the important fact that the oneway velocity of energy propagation of light is $\mathbf{c}$ with respect to absolute space, where $c = |\mathbf{c}|$ is a universal constant. This velocity $\mathbf{c}$ relative to absolute space is found to be independent of the velocity of the source. The observed velocity of light $\mathbf{c}^*$ is found to be a function of the absolute velocity of the observer (or detector) $\mathbf{v}$, such that

$$\mathbf{c}^* = \mathbf{c} - \mathbf{v}, \tag{1.15}$$

where $\mathbf{v}$ is taken positive in the $\mathbf{c}$ direction receding from the source. The observed oneway velocity of light $\mathbf{c}^*$ is thus anisotropic with respect to the observer.

The energy propagation of light behaves precisely as sound in air; as though absolute space were filled with a stationary medium or a fixed luminiferous ether.



Even though it may be obvious that a body must have an absolute velocity; it is extremely difficult to detect and to measure. The behavior of the oneway velocity of energy propagation of light, as given by Eq.(1.15), provides a means of detecting and measuring the absolute velocity $v$ of an observer or detector or of a body.

1.7a The observations of Roemer – The observations of Roemer (1677), repeated with greater accuracy by Halley (1694), are readily explained by Eq.(1.15). Roemer noted the variation in the period T of Jupiter's inner moon Io when the Earth approached Jupiter, $T_+ = T_o(1 - v_+/c)$ and when the Earth receded from Jupiter, $T_- = T_o(1 + v_-/c)$. He was thereby the first to measure the velocity of light, as given by

$$c = v_o(T_- + T_+)/(T_- - T_+)\,, \tag{1.16}$$

where $v_o$ is the known orbital velocity of the Earth about the Sun.

The Roemer method for determining c may also be regarded as utilizing the first order Doppler effect when the Earth approaches Jupiter as compared with the Doppler effect when the Earth recedes from Jupiter.

The effect of the constant absolute velocity of the solar system itself cancels out upon comparing the periods 6 months apart; thus, for

$$v_+ = v_s + v_o \quad \text{and} \quad v_- = v_s - v_o, \qquad v_+ - v_- = 2v_o, \tag{1.17}$$

where here $v_s$ is the component of the absolute velocity of the solar system in the Earth–Jupiter direction.

The Roemer result (known to Newton) is clear evidence for the existence of absolute space. It also reveals the fact that the oneway velocity of light with respect to this space is c, the value obtained by Roemer. His observations prove that the observed oneway velocity of light $\mathbf{c}^*$ depends upon the velocity of the observer, the moving Earth. The *relative* velocity between the Earth and Jupiter is not involved; because Jupiter remained almost stationary relative to the fixed stars, while the Earth observer did the moving.

1.7b The observations of Bradley – Bradley (1728) noted an

apparent annual angular displacement of all stars, which is also explained by Eq.(1.15), as illustrated by the vector diagram in Fig. 1.1 for a particular stellar source, showing the aberration

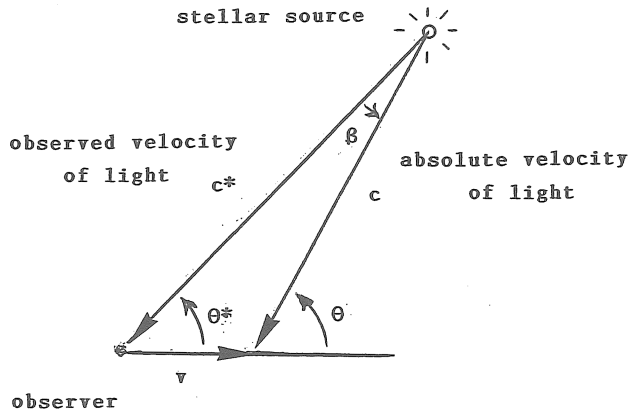



Fig. 1.1 Diagram for Bradley stellar aberration.

angle $\beta$, which measures the angular displacement of a star from its true position $\Theta$ to an apparent position $\Theta^*$, as measured from the forward direction of the absolute velocity $\mathbf{v}$ of the observer.

From the law of sines applied to the triangle shown in Fig. 1.1,

$$\sin\beta = (v/c)\sin\Theta^*. \tag{1.18}$$

For a star observed to be perpendicular to the ecliptic, where $\Theta^* = \pi/2$, Bradley observed the difference between the apparent angular position of the star 6 months apart. In this case Eq.(1.18) yields, using Eq.(1.17)

$$\sin\beta_+ - \sin\beta_- = (v_+ - v_-)/c = 2v_o/c. \tag{1.19}$$

The star appears to move in a small circle, where the angular radius from the center of the circle, for $\sin\beta \simeq \beta$, is given by

$$\beta = v_o/c. \tag{1.20}$$

From the known value of the velocity $v_o$ of the Earth in orbit about the Sun and the measured value of $\beta$ Bradley was the second



to obtain the value of the velocity of light using Eq.(1.20). Bradley's value agreed with the value obtained previously by Roemer; which is not surprizing, as both the transverse observations of Bradley and the longitudinal observations of Roemer are explained by precisely the same formula (1.15).

Although the observations of Roemer and Bradley do not yield the value of the absolute velocity of the solar system $\mathbf{v}_o$; they reveal the effect of absolute space and the absolute velocity of the observer $\mathbf{v}$ on the observed velocity of light $\mathbf{c}^*$, as given by Eq.(1.15). In addition, Bradley's result reveals the important fact that the velocity of the source does not affect the velocity of light. No matter how different nor how fast the various stars may be moving, they all reveal precisely the same Bradley aberration. In particular, if the velocity of light were $\mathbf{c}$ relative to a moving source, then Eq.(1.20) would have to be replaced by $\beta = v_o/|\mathbf{c} + \mathbf{v}'|$; and for sources with velocities $\mathbf{v}'$ approaching the velocity of light the aberration circle should either vanish or become very large.

1.7c The Sagnac experiment - The setup for the Sagnac (1913) experiment is diagrammed in Fig. 1.2. The entire setup, including the source, the mirrors, and the detector are mounted rigidly to a turntable, as shown. Light from the source S is split into two beams, $B_1$ and $B_2$, at the semitransparent mirror $M_o$. The transmitted beam $B_1$ is then reflected form mirrors $M_1$ , $M_2$, and $M_3$ to again be transmitted through $M_o$ to arrive at the detector O. The beam $B_2$ reflected from $M_o$ is then reflected from mirrors $M_3$, $M_2$, and $M_1$ to again be reflected from $M_o$ to also arrive at the detector O, where it interferes with beam $B_1$.

When the turntable is rotated with the angular velocity $\Omega$, the interference intensity is observed to change. Since there is no relative motion of any of the parts of the setup; the effect is necessarily a product of the fact that the velocity of light $\mathbf{c}$ is fixed with respect to absolute space.

The beam $B_1$, that travels around the closed path in the direction of rotation, must travel farther; because the mirror $M_o$ will have moved the distance

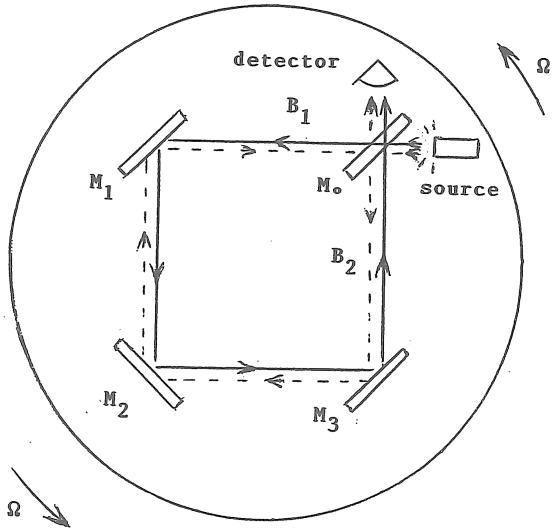



Fig. 1.2 Diagram for the Sagnac experiment.

$$R\Omega\Delta t, \tag{1.21}$$

where R is the distance to the center of rotation, in the time $\Delta t$ that it takes beam $B_1$ to travel around the closed path. And beam $B_2$, that travels counter to the direction of rotation $\Omega$, travels a distance shortened by the amount given by Eq.(1.21). If c is the mean speed of the light with respect to the laboratory as it travels around the setup, then the time for light to go around the setup is given by $\Delta t = P/c$, where P is the perimeter of the closed light path. Since it may be proved for any closed path that $RP = 2A$, where A is the area enclosed (such as for a circle, where $P = 2\pi R$ and $A = \pi R^2$); the time $\Delta t$ for light to go around the closed path is given by

$$\Delta t = 2A/cR. \tag{1.22}$$

The optical path length difference between the two beams $B_1$ and $B_2$ is then given from Eqs.(1.21) and (1.22) by

$$D = 2R\Omega\Delta t = 4A\Omega/c. \tag{1.23}$$



If the laboratory is moving with the uniform absolute velocity v, the effective velocity of light, averaging $c^* = c - v$ around the closed path becomes simply c.

The Sagnac experiment demonstrates the fact that the velocity of light does not partake of the velocity of the source. If the velocity of light were c relative the source, no Sagnac effect would be observed

1.7d The Michelson-Gale experiment - Michelson and Gale (1925) performed the Sagnac experiment using the rotating Earth itself at a northern latitude as the turntable. Since $\Omega$ was fixed; the results were compared for two different areas A, Eq.(1.23). In this case it is again clear that the velocity of light is c with respect to absolute space; and it cannot be simply chosen as c relative to a laboratory frame of reference fixed to the surface of the rotating Earth.

The Michelson-Gale experiment yields the *absolute* rotational velocity of the Earth $\Omega$ for A and c known. It, thus, demonstrates the existence of an absolute centripetal acceleration; and absolute accelerations in general that are needed to make local physical laws valid, in addition to Newton's second law. It may be noted that the zero absolute rotational velocity frame, determined by Michelson-Gale locally, coincides with the stationary nonrotating celestial sphere.

Instead of the hours needed by the Foucault pendulum experiment to measure the angular velocity of the rotating Earth locally, the Michelson-Gale result can be obtained within a fraction of a second in principle. Consequently the Michelson-Gale experiment yields essentially the *instantaneous absolute* tangential velocity $v_r$ of the Earth's surface, $v_r = r\Omega$, where r is the radial distance to the Earth's axis. In this way the Michelson-Gale experiment further demonstrates the existence of *absolute* linear velocities and absolute space.

The Michelson-Gale experiment also reveals the fact that the

velocity of light is not c relative to the source on the surface of the moving Earth. If it were, no effect would be observed. The velocity of light is c relative to absolute space independent of the velocity of the Earth's surface. The Michelson-Gale result is not a laboratory effect; it is a real *astronomical* effect.

1.7e The Doppler shift of light from distant galaxies to detect absolute space - The first order Doppler effect for light is the same as for sound. Thus, the observed frequency $\nu_o'$ of light emitted from a source of frequency $\nu_s'$ moving with the absolute velocity $\mathbf{v}_s'$ observed by an observer moving with the absolute velocity $\mathbf{v}_o'$ is given by

$$\nu_o' = \nu_s'(1 - \mathbf{c}\cdot\mathbf{v}_o'/c^2)/(1 - \mathbf{c}\cdot\mathbf{v}_s'/c^2) \simeq \nu_s'\left[1 - \mathbf{c}\cdot(\mathbf{v}_o'-\mathbf{v}_s')/c^2\right], \quad (1.24)$$

where $\mathbf{v}_s'$ is taken positive in the direction toward the observer and $\mathbf{v}_o'$ is taken positive in the direction of c receding from the source.

From the cosmological principle that the universe is isotropic in-the-large, the velocities of galaxies may be assumed to be distributed randomly in magnitude and direction. Thus, the frame of reference yielding a net zero Doppler shift for light from distant galaxies defines an absolute zero velocity frame, or absolute space. In particular, the absolute velocity of the solar system, or Earth observer, is the velocity $\mathbf{v}_o'$ that minimizes the observed red shifts. The cosmological red shift, being a function of distance only, cancels out for a spherical shell of galaxies equidistant from the Earth, or for a uniform distribution of galaxies in depth.

In this way Hubble (1939) estimated from observations that the absolute velocity of the solar system is $v_s$ = 300 km/s, right ascension $\alpha_s = 3.3^h$, and declination $\delta_s = 55°$. Subsequently de Vaucouleurs and Peters (1968), examining the red shifts of 204 Galaxies within 75 Mps from the Earth, obtained $v_s = 300 \pm 50$ km/s, $\alpha_s = 7 \pm 1^h$, and $\delta_s = 50 \pm 10°$. And Rubin et al (1976), examining a shell of 200 galaxies at a distance of 100 Mps, obtained $v_s = 600 \pm 100$ km/s, $\alpha_s = 2 \pm 2^h$, and $\delta_s = 50 \pm 20°$.

Although this method does not provide an accurate determination



of the absolute velocity of the observer, or solar system; it is in rough agreement with other independent ways of determining the absolute velocity of the solar system (see below); so these observations also contribute to the evidence for the existence of absolute space.

1.7f Marinov's coupled mirrors measurement of the absolute velocity of the closed laboratory - The measurement of absolute velocities in the closed laboratory was first achieved by Marinov (1974, 1980a) with his brilliant coupled mirrors experiment. (A detailed description and suggested improvements can be found in a book by Wesley 1991a.) By comparing the difference in the oneway velocity of light in opposite directions down a rotating shaft he obtained, using Eq.(1.15), the absolute velocity of the closed laboratory as

$$\mathbf{v} = (\mathbf{c}_-^* - \mathbf{c}_+^*)/2, \quad (1.25)$$

for the orientation of the shaft L, as shown in Fig. 1.3, in the direction of $\mathbf{v}$.

The oneway velocity of light was registered by the angle $\delta\Theta_+$ through which the shaft rotated during the time $\delta t$ that it took light to travel down the shaft of length L; thus,

$$c_+^* = c - v_L = L/\delta t = L\Omega/\delta\Theta_+, \quad (1.26)$$

where $v_L$ is the component of the absolute velocity of the setup in the direction of the shaft and $\Omega$ is the angular velocity of the shaft. The small angle $\delta\Theta_+$ was registered interferometrically by splitting a light beam at the semitransparent mirror $M_3$, as shown in Fig. 1.3, and letting beam a be reflected from the initial mirror $M_1$ and beam b be reflected from the final mirror $M_2$. The two beams were then recombined, as shown, and the resulting interference intensity registered by a photodiode P. The optical path difference of interest, that registered $\delta\Theta_+$, was then given by $2r\delta\Theta_+ = 2r\Omega\delta t$, where r is the radius of the shaft. Using Eq.(1.26), the light intensity registered at P was given by

$$I_+ = I_o\cos^2(2\pi r\delta\Theta_+/\lambda) = I_o\cos^2\left[\phi_o/2(1 - v_L/c)\right], \quad (1.27)$$

where

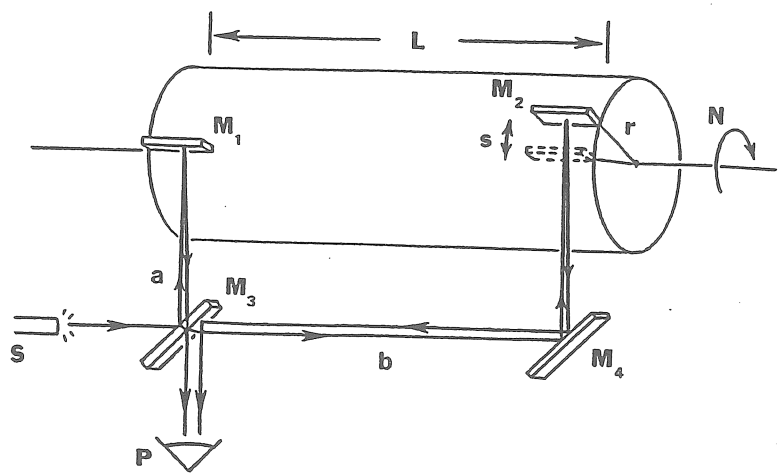



Fig. 1.3 Diagram of the Marinov coupled mirrors experiment, indicating one light beam in one direction only. The independent light beam in the opposite direction is not shown, nor is the all important electronic bridge shown, that yields the desired *difference* $(c_-^* - c_+^*)/2$.

---

$$\phi_o = 4\pi L \Omega r/\lambda c, \tag{1.28}$$

a constant independent of $v_L$ that was adjusted by the appropriate choice of $\Omega$ to equal $\pi/2$. For $v_L/c$ small the observed intensity was then

$$I_+ = I_o(1/2 - \pi v_L/4c). \tag{1.29}$$

An independent light beam from an independent light source was sent down the rotating shaft in the opposite direction. Using independent mirrors an independent interference intensity $I_-$ was obtained, that was equal to $I_+$, as given by Eq.(1.29), with the minus sign changed to a plus sign. Marinov employed the ingenious stratagem of comparing the interferometric light intensities, as



measured by the photodiode output currents *directly* in an electronic bridge. Differences in light intensities to a fractional difference of the order of $10^{-5}$ can be distinguished by this clever stratagem. In this way Marinov obtained for $\Delta I = I_- - I_+$ the result

$$v_L = (2\Delta I/\pi I_o)c. \tag{1.30}$$

The absolute velocity of the laboratory includes the tangental velocity of the Earth's surface due to rotation, less than 0.47 km/s, the orbital velocity of the Earth about the Sun, about 30 km/s, and the largest component, the absolute velocity of the solar system, about 300 km/s. Marinov's coupled mirrors result provides the most accurate value of the absolute velocity of the solar system $v_s$ as yet obtained. He found $v_s = 300 \pm 20$ km/s, $\alpha_s = 13.3 \pm 0.3^h$, and $\delta_s = -20 \pm 4°$.

1.7g Marinov's toothed wheels measurement for the absolute velocity of the closed laboratory – Because many were confused by his elegant coupled mirrors method for measuring the absolute velocity of the closed laboratory; Marinov (1980b) performed an elementary Fizeau type experiment, using two toothed wheels mounted on the ends of a rotating shaft, as shown in Fig.1.4. (See also the description by Wesley 1991b). In this experiment the oneway velocity of laser light down a rotating shaft is registered by change in the amount of light that manages to pass between the teeth of both of the toothed wheels, that are displaced relative to each other during the time it takes light to travel down the rotating shaft, as indicated in Fig.1.5.

The displacement of the gap between two teeth, or holes, $s_\pm$ during the time light travels down the shaft of length L with the velocity $c_\pm^* = c \mp v_L$ is given by

$$s_\pm = R\Omega L/(c \mp v_L) \simeq (R\Omega L/c)(1 \pm v_L/c), \tag{1.31}$$

where R is the radial distance to the gap, and $\Omega$ is the angular velocity of the shaft, and where $v_L$ is the absolute velocity in the direction L. The intensity registered by a photodetector is then

$$I_\pm = I(1 - 2s_\pm/b), \tag{1.32}$$

where the alignment of the laser beams for $\Omega = 0$ are adjusted so

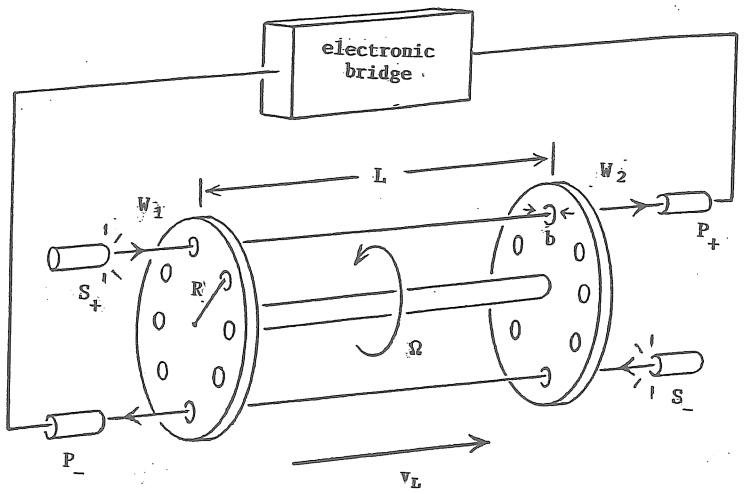



Fig. 1.4 Diagram for Marinov's toothed-wheels experiment to measure the absolute velocity of the laboratory $v_L$.

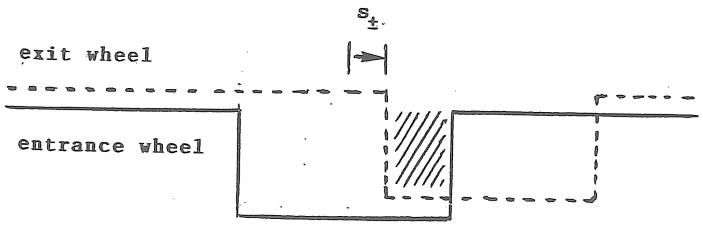



Fig. 1.5 Gap alignments between entrance and exit wheels for Marinov's toothed wheels experiment. For shaft stationary laser beams are adjusted to yield half maximum intensity. When shaft is rotated, time retardation produces a misalignment that decreases the fractional intensity by $-2s/b$. The shaded portion indicates light transmission.



$I_o$ equals onehalf the maximum intensity to obtain the maximum sensitivity.

Subtracting Eqs.(1.32) and using (1.31) yields

$$(I_- - I_+)/I_o = 2(s_+ - s_-)/b = (4R\,\Omega L/c^2 b)v_L. \tag{1.33}$$

The coefficient of $v_L$ on the right side of Eq.(1.33) is determined by noting that

$$\Delta I/2I_o = (2I_o - I_- - I_+)/2I_o = 2R\,\Omega L/cb \tag{1.34}$$

where $\Delta I$ is a readily measureable difference in the intensity between when the shaft is stationary and when it is rotating. Substituting Eq.(1.34) into (1.33) the desired component in the direction L of the absolute velocity of the laboratory is then given by

$$v_L = c(I_- - I_+)/2\,\Delta I. \tag{1.35}$$

The very small difference in intensity $(I_- - I_+)$ is determined by the clever stratagem of measuring the difference in the current outputs of the two photodiodes directly in an electronic bridge, as indicated in Fig. 1.4.

This result (1.35) is valid for any shaped gap, including circular holes; since for small displacements $s_\pm$ the intensity is always a linear function of $s_\pm$.

This trivially simple method is less accurate than the coupled-mirrors interferometric measurement; but it indicates the principles involved in a manner that is clear and cannot be misinterpreted.

Marinov obtained by this method the absolute velocity of the solar system as $v_S = 360 \pm 40$ km/s, $\alpha_S = 12 \pm 1^h$, and $\delta_S = -24 \pm 7°$.

It is important to note that no beam chopping is actually necessary, The lasers, the toothed wheels, the shaft and the photodetectors can all be rigidly mounted together; and the entire setup then rotated. Since there is then no relative motion between any parts of the setup; the result is a product of the *absolute* rotation only. This is similar to the Sagnac experiment, where there is no relative motion between any parts of the setup; and only the *absolute* rotation is involved. The Sagnac result may

be regarded as a longitudinal effect, where the equipment moves in the direction of the light; while the Marinov toothed wheels result may be regarded as a transverse effect, where the equipment moves transverse to the direction of the light.

1.7h Müller-Means determination of the velocity of the solar system using geostationary satellite data - Müller and Means (1994) determined the absolute velocity of the solar system using the difference in arrival times at two Earth stations A and B of radio time signals emitted by geostationary satellites. Considering the geometry and the fact that the velocity of light and radio signals is c with respect to absolute space, the difference in arrival times of a signal at stations A and B, $t_{AB}$, is given by

$$ct_{AB} = C + L\cdot v_e/c, \tag{1.36}$$

where C is a constant independent of the time of day and L is the vector base line from station A to station B, that rotates with the Earth once a day, and where $v_e$ is the absolute velocity of the Earth equal to $v_o + v_s$, where $v_o$ is the Earth's orbital velocity about the Sun and $v_s$ is the absolute velocity of the solar system. Since the atomic clocks at the two Earth stations can be synchronized to within about 100 nanoseconds, $10^{-7}$ s; this method is feasible to determine $v_s$ from Eq.(1.36), considering different times of day.

Using data from 3 geostationary satellites and 3 Earth stations, Müller and Means obtained $v_s = 250 \pm 50$ km/s, $\alpha_s = 6 \pm 1^h$, and $\delta_s = -14 \pm 3°$.

The Müller-Mean result further confirms the existence of absolute space in which the velocity of light is c. (Although this method is straightforward and valid; Müller has expressed in private some uncertainty about the data available.)

## 1.8 Proposed Methods to Measure Absolute Velocity from the Anisotropy of the Oneway Velocity of Light c*

Considering the evidence presented above in Section 1.7 for determining the absolute velocity from the anisotropy of the observed oneway velocity of light c*, as given by Eq.(1.15) and



(1,25), *absolute* velocities can be readily measured, at least to within a 3 place accuracy for v/c. The problem now is to find the *most accurate* method. The problem becomes one of designing a possible practical *absolute* tachometer.

1.8a Annual variation of pulsar periods for absolute velocity - The annual variation in pulsar periods provides a method to measure the absolute velocity of the solar system. The period $T_o$ of a pulsar should exhibit a first order Doppler effect as given by Eq.(1,24); thus,

$$T = T_o(1 + c\cdot v_e/c^2), \tag{1.37}$$

where $T_o$ is the period of the pulsar for an observer at absolute rest and $v_e$ is the absolute velocity of the observer or Earth receding from the pulsar. The velocity of the observer is primarily equal to the velocity of the Earth in orbit about the Sun $v_o$ plus the absolute velocity of the solar system $v_s$; thus,

$$v_e = v_o + v_s; \tag{1.38}$$

so Eq.(1.37) becomes

$$T = T_o(1 + v_{op}/c + v_{sp}/c), \tag{1.39}$$

where $v_{op} = c\cdot v_o/c$ and $v_{sp} = c\cdot v_s/c$ are the components of the velocities of the Earth and Solar system in the direction of the pulsar.

Considering the date when the Earth is receding most rapidly from the pulsar, so $v_{ep} = v_{op}(max)$, and the pulsar period is $T_+$ and 6 months later when the Earth is approaching the pulsar most rapidly and the period is $T_-$, Eq.(1.39) yields

$$v_{sp} = v_{op}(max)(T_+ + T_-)/(T_+ - T_-) - c. \tag{1.40}$$

By considering 3 or more widely separated pulsars the magnitude and direction of the absolute velocity $v_s$ of the solar system can be determined from Eq.(1.40).

The reported accuracy of pulsar periods out to 9 places or more should make this method of determining the absolute velocity of the solar system feasible.

(Considering the great interest shown in changes in pulsar

periods with time, it seems that annual variations in pulsar periods should have been reported. But I have been unable to find any published information about annual changes in pulsar periods. Nor have I been able to receive any information from radio observatories nor radio astronomers. If anyone has the requisite information, they need only plug in the appropriate numbers into Eq.(1.40) to obtain the absolute velocity of the solar system in magnitude and in direction.)

1.8b Independent clocks to measure absolute velocity - Instead of mounting two toothed wheels on the ends of a rotating shaft, as done by Marinov (Section 1.7g above), to obtain the absolute velocity of the setup, the toothed wheels can be driven by two independent identical clock motors (Wesley 1989). The clocks may be assumed to run at the same rate to within a small fractional difference that produces a phase drift that is insignificant over the time of an observation. In this way the distance that the light travels L can be made kilometers long instead of only meters; and the accuracy can be correspondingly enhanced. Two independent identical laser sources, as shown in Fig. 1.6, create two light beams each, $B_1$ and $B_2$ at the semitransparent mirror $M_1$, and $B_3$ and $B_4$ at the semitransparent mirror $M_3$. Beams $B_1$ and $B_2$ are passed between neighboring gaps of the toothed wheel $W_1$ of width b separated by the distance d, as indicated in Fig. 1.7. With both wheels stationary the mirrors are aligned so the beams $B_1$ and $B_2$ arrive at the toothed wheel $W_2$ only a distance (d - b) apart to yield half maximum intensities that pass through the corresponding gaps between the teeth of wheel $W_2$. Similarly, $B_3$ and $B_4$ arrive at toothed wheel $W_1$ a distance (d - b) apart.

If the component of the absolute velocity of the setup is $v_L$ in the direction from toothed wheel $W_1$ to $W_2$, the gap in toothed wheel is displaced laterally the distance $s_+ = R\Omega\Delta t_+$, where R is the radius fo the wheels and $\Omega$ is their angular velocity, in the time $\Delta t_+$ it takes light to travel the distance L, where

$$\Delta t_+ = L/c_+^* = L/(c - v_L) \simeq (L/c)(1 + v_L/c), \qquad (1.41)$$

The amount of light passing through the gaps in toothed wheel $W_2$ is



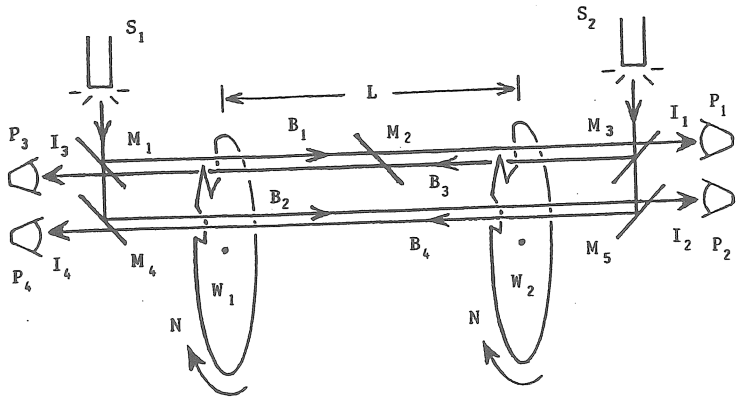



Fig. 1.6 Diagram for the proposed experiment to measure absolute velocity using two toothed wheels driven by two independent clocks. (Reproduced from *Physics Essays* 2, 334 (1989).)

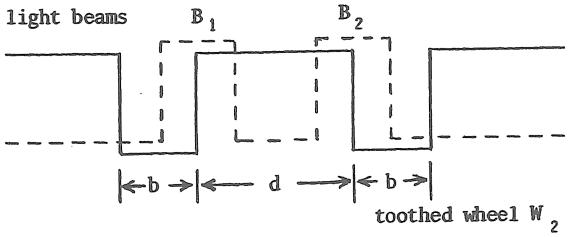



Fig. 1.7 Diagram indicating the alignment of light beams $B_1$ and $B_2$ from toothed wheel $W_1$ relative to the gaps in toothed wheel $W_2$. (Reproduced from *Physics Essays* 2, 334 (1989).)

thus decreased for beam $B_1$ and increased for $B_2$ by the fractional amount $2s_+/b$. The intensities received by the four independent photodetectors when both wheels are rotating in phase are then to first order in $v_L/c$

$$I_1 = I_o(1 + K + Kv_L/c), \qquad I_2 = I_o(1 - K - Kv_L/c),$$
$$I_3 = I_o(1 - K + Kv_L/c), \qquad I_4 = I_o(1 + K - Kv_L/c), \tag{1.42}$$

where $I_o = I(max)/2$ and $K = 2R\Omega L/cb$.

Differences in the time average photodetector currents, that are proportional to the difference in intensities, $\Delta I_{12} = I_1 - I_2$, etc., can be accurately measured in an electronic bridge. The desired absolute velocity component $v_L$ is then given from Eqs.(1.42) by

$$v_L = (\Delta I_{12} - \Delta I_{43})/(\Delta I_{12} + \Delta I_{43}). \tag{1.43}$$

The relative phase of the two independent toothed wheels with their clocks can be readily controlled by rotating one of the clocks together with its wheel until the individual intensities, $I_1$, $I_2$, $I_3$, and $I_4$ are each half maximum.

It is important to note that the photodetectors and lasers can be rigidly mounted to the corresponding toothed wheels to rotate with the toothed wheels; so no beam chopping is involved and no relative motion of any of the parts of the setup is involved when the toothed wheels rotate in phase. Like the Sagnac experiment, only a rotation with respect to absolute space is then involved. When attached, the stability of the alignments is greater.

1.8c Proposed oneway Sagnac device to measure absolute velocity - The proposed device (Wesley 1994) is shown in Fig. 1.8. Light from the source S is split into two beams at the semitransparent mirror $M_o$ so that one beam passes halfway around the Sagnac (1913) setup in the direction of rotation and the other beam passes halfway around the setup in the direction counter to the rotation. After reflection and transmission of the two beams at the semitransparent mirror $M_3$, the two beams interfere and the interference intensity is detected by the photodetector O.

During the time $\Delta t$ for light to go halfway around the closed path mirror $M_3$ is displaced relative to $M_o$ by the distance

$$D = R\Omega\Delta t, \tag{1.44}$$

where, neglecting the absolute velocity of the device, $\Delta t = P/2c$, where P is the perimeter of the closed path (cf. Eq.(1.21)). In



terms of the area A enclosed Eq.(1.23) yields the displacement as

$$D = 2A\Omega/c. \tag{1.45}$$

Considering the square perimeter shown in Fig. 1.8, the optical path from mirror $M_o$ to $M_2$ is given by

$$P_{o2} = cL/c_{o2}, \tag{1.46}$$

where the mean velocity $c_{o2}$ to first order in v/c is given by

$$c_{o2} = c - L\Omega/2 - v_p \sin(\Omega t - \phi_o + \pi/4), \tag{1.47}$$

where $L\Omega/2$ accounts for the time delay to reach the receding mirror $M_2$, the angle $\Omega t$ is measured from the positive x axis, and $\phi_o$ is the angle $v_p$ makes with respect to the positive x axis, where $v_p$ is the component of the absolute velocity of the setup in the plane of the device. Similarly the optical path lengths along the other three portions of length L may be computed. The net path length difference for beams travelling from right to left as shown in Fig. 1.8 is then (1.48)

$$D_+ = P_{o2} + P_{23} - P_{o1} - P_{13} = D\left[1 + \sqrt{2}(v_p/c)\cos(\Omega t - \phi_o)\right],$$

where D is given by Eq.(1.45).

A second independent source produces two beams passing through the device in the opposite direction to yield an independent interference intensity detected by an independent photodetector, where the optical path difference is given by Eq.(1.48) by replacing $v_p$ by $-v_p$. The difference between the interference intensities $\Delta I = (I_+ - I_-)$ registered by the photodetectors can be measured directly accurately by comparing the output currents in an electronic bridge. The fractional difference is then

$$\Delta I/I = 2(I_+ - I_-)/(I_+ + I_-) = 2\cos^2(\pi D_+/\lambda) - 2\cos^2(\pi D_-/\lambda). \tag{1.49}$$

To first order in $v_p/c$ Eqs.(1.48) and (1.49) yield

$$\Delta I/I = A(v_p/c)\sin(\Omega t - \phi_o). \tag{1.50}$$

where the constant $A = (8\sqrt{2}\,\pi D/\lambda)\sin(\pi D/\lambda)$, To realize a maximum effect it is convenient to choose $\pi D/\lambda = \pi/2$; so $A = 4\sqrt{2}\,\pi$; and

$$\Delta I'/I = (4\sqrt{2}\,\pi v_p/c)\cos(\Omega t - \phi_o). \tag{1.51}$$

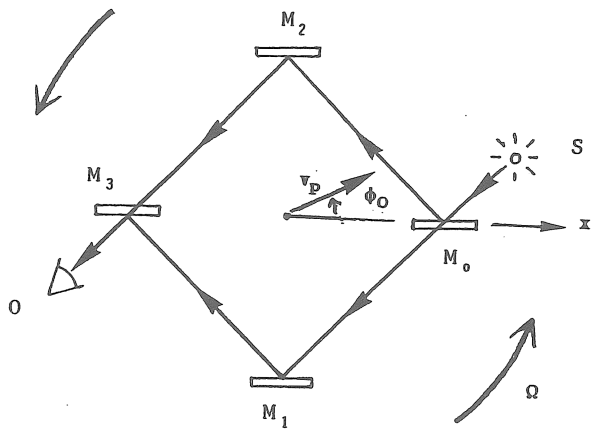



Fig. 1.8 Oneway Sagnac device where the two interfering light beams travel essentially in one direction only, from right to left as shown. The independent interfering light beams travelling in the opposite direction from left to right are not shown.

The magnitude of the component of the absolute velocity in the plane of the device $v_p$ may be obtained from the root mean square vlaue of $\Delta I'$; thus,

$$v_p = c\,\Delta I'_{rms}/4\pi I. \qquad (1.52)$$

The direction of $v_p$ in the plane of the device can be obtained by putting the difference signal, Eq.(1.51) on an oscilloscope and noting when $\Delta I'$ is a maximum, when $\phi_o = \Omega t$.

Since a *difference* in intensities is being measured directly with an electronic bridge; considerable accuracy can be obtained. An added advantage is a sinusoidal signal is produced that can be readily amplified and filtered from any stray unwanted signals. It seems that a 3 or 4 place accuracy for the absolute velocity as v/c should be readily obtainable.

For a northern (or southern) latitude the plane of the device changes its orientation during the day; so the 3rd component of the



absolute velocity of the solar system $v_s$ can be readily deduced.

1.8d Proposed oneway Michelson-Gale experiment to measure the equatorial component of absolute velocity of the Earth - The proposed setup (Wesley 1999a), as indicated in Fig. 1.9, is laid

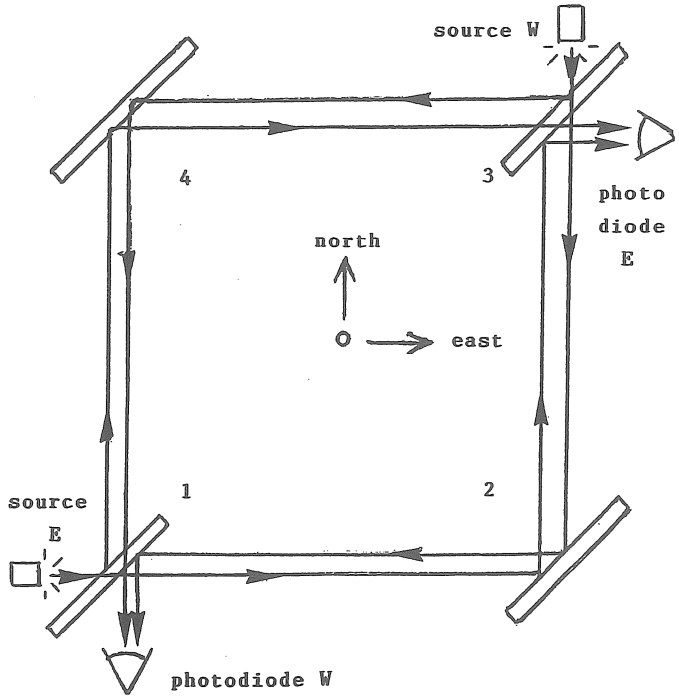



Fig. 1.9 Diagram of the oneway Michelson-Gale experiment for the eastward component of the absolute velocity of the setup $v_E$ at a northern latitude, obtained by comparing the interference intensity produced by two beams travelling from the southwest corner to the northeast corner with the interference intensity produced by two independent beams travelling in the opposite direction.

out on the surface of the rotating Earth at a northern (or southern) latitude, where the distance between mirrors L can be of the order

of a kilometer. Since the setup can only rotate about the Earth's axis as the Earth turns; the effective plane of the setup is the equatorial plane; and only the equatorial component of the absolute velocity of the Earth can be measured by this method.

Light from a laser E at the southwest corner of the square is split into two beams by the semitransparent mirror $M_1$. The transmitted beam follows the southern route to mirror $M_2$, where it is reflected to the semitransparent mirror $M_3$ and then to the photodiode E at the northeast corner of the square. The reflected beam follows the northern route to Mirror $M_4$, where it is reflected to the semitransparent morror $M_3$ and then also to the photodiode E, where it interferes with the transmitted beam.

Due to the Earth's rotation the southern route, being farther from the Earth's axis, is longer by $D_E$ than the northern route in the time $\Delta t_E$ that it takes light to pass from the west side to the east side of the square, where

$$D_E = (L\Omega \sin\delta)\,\Delta t_E\,, \tag{1.53}$$

where $\delta$ is the latitude, $\Omega$ is the Earth's angular velocity, and

$$\Delta t_E = L/(c - v_E) \simeq (1/c)(1 + v_E/c), \tag{1.54}$$

where $v_E$ is the east component of the absolute velocity of the setup.

The interference intensity from Eqs.(1.53) and (1.54) is then given by

$$I_E = 4I_o \cos^2(\pi D_E/\lambda) = 4I_o \cos^2\left[K(1 + v_E/c)\right], \tag{1.55}$$

where the constant K is given by

$$K = \pi L^2 \Omega \sin\delta / c\lambda. \tag{1.56}$$

For convenience in the analysis K may be chosen as $K = (1 + 2n)\pi/4$, where n is an integer, by choosing L appropriately (of the order of 0.3 km and greater). For this choice Eq.(1.55) yields

$$I_E = 2I_o\left[1 - \sin(\pi v_E/2c)\right] \simeq 2I_o(1 - \pi v_E/2c), \tag{1.57}$$

to first order in $v_E/c$.

For the light beams travelling in the opposite direction from the northeast corner to the southwest corner the interference intensity becomes from Eq.(1.57), replacing $v_E$ by $-v_E$,



$$I_E = 2I_o(1 + \pi v_E/2c). \tag{1.58}$$

The difference in intensities can be measured accurately using an electronic bridge. The desired component of the absolute velocity is then

$$v_E = 2c(I_W - I_E)/\pi(I_W + I_E). \tag{1.59}$$

The component $v_E$ changes during the day, such that

$$v_E = -v_p \sin(\Omega t - \alpha_s), \tag{1.60}$$

where $\Omega t$ is the right ascension of the setup at the time t, $v_p = v\cos\delta_s$ is the magnitude of the component of the absolute velocity in the equatorial plane and $\alpha_s$ is its right ascension.

In contrast to the difficulties and costs of the original Michelson-Gale (1925) experiment, involving long evacuated pipes, the proposed oneway Michelson-Gale experiment can be accomplished easily and cheaply, using light fibers, that have been developed for communication, and can transmit light a distance of 2 km without being amplified. The relative phase of the two interfering beams, as indicated in Fig. 1.9, remains the same using light fibers as in empty space. This behavior is to be expected from the fixed time delay theory for the propagation of light in a moving medium (Hoek 1868, Kosowski 1978, Marinov 1977b, and Wesley 1991c). The velocity of light between attachment centers is c precisely the same as in empty absolute space. The apparent decrease in the net velocity of light in a medium is due to the fixed time delays when the light becomes attached to centers in the medium. Thus, two beams traversing the same amount of material and experiencing the same time delay will exhibit the same relative phase difference as when transmitted through empty space. This conclusion is verified by the same result being obtained for the Sagnac experiment in a material medium moving with the setup (Pogany 1938, Marinov 1977c, 1978). The practical light gyrocompass using light fibers, based upon the Sagnac experiment, provides dramatic proof of the fixed time delay theory for the transmission of light in a moving medium.

1.8e Proposed cavity resonator for absolute velocity – A cavity containing electrodynamic radiation resonates in the lowest

mode when the wavelength $\lambda$ is twice the length L of the cavity. The wavelength equals the out and back *phase* velocity $c_c$ divided by the frequency $\nu$; so measuring the length of a cavity and its lowest resonating mode frequency yields a value for the out and back phase velocity; thus,

$$c_c = \lambda\nu = 2L\nu . \tag{1.61}$$

This value $c_c$ is reported in the tables of fundamental constants as *the velocity of light* c with a numerical value given out to 9 decimal places (see for example, the table prepared by Cohen and Taylor 1999).

Unfortunately, for a moving cavity the out and back phase velocity $c_c$ does not equal c, the oneway velocity of energy propagation relative to absolute space, that *is* a universal constant. Moreover, the out and back phase velocity $c_c$ appropriate for a moving resonating cavity is not a constant. It depends upon the absolute velocity v of the cavity and is given by

$$c_c = c(1 - v^2/c^2). \tag{1.62}$$

This result (1.62) explains the Michelson-Morley null result. Each arm of the Michelson interferometer forms a cavity resonator for standing light waves. Since the out and back phase velocity $c_c$ , Eq.(1.62), is independent of the orientation of the cavity L; two cavities oriented ar right angles to each other (or any other angle) excited by a common coherent (in phase) source, as provided by the central semitransparent mirror in the Michelson-Morley experiment, can exhibit no altered interference (or phase difference) with a change in the orientation of the setup. Michelson made the error (frequently made) of assuming that the oneway phase velocity of light $\mathbf{c}'$ should be the oneway velocity of energy propagation, as given by $\mathbf{c}^* = \mathbf{c} - \mathbf{v}$, Eq.(1.15).

The result (1.62) may be derived from the phase change of light travelling out and back in a cavity. The oneway phase velocity $\mathbf{c}'$ of light as seen by an observer moving with the absolute velocity $\mathbf{v}$ is given by the Voigt (1887)-Doppler effect for light (as has been fully discussed by Wesley 1980, 1983, 1986, 1991d) as

$$\mathbf{c}' = \mathbf{c} - \mathbf{v} - \left[\mathbf{v} \times (\mathbf{v} \times \mathbf{c})/v^2\right]\left[1 - \sqrt{1 - v^2/c^2}\right]. \tag{1.63}$$



This value of $\mathbf{c}'$ differs from the oneway velocity of energy propagation, $\mathbf{c}^* = \mathbf{c} - \mathbf{v}$, by the third term on the right of Eq.(1.63), where $\mathbf{v} \times (\mathbf{v} \times \mathbf{c})/v^2$ merely represents the component of $\mathbf{c}$ perpendicular to $\mathbf{v}$. (It may be noted that the Voigt-Doppler effect is the usual accepted Doppler effect falsely called the "special relativistic Doppler effect".) The magnitude of the oneway phase velocity $\mathbf{c}'$ from Eq.(1.63) is then

$$c' = c(1 - \mathbf{v}\cdot\mathbf{c}/c^2), \tag{1.64}$$

which is precisely the same as for sound.

Since the *phase* velocity is responsible for the standing wave in a cavity; $\mathbf{c}'$ must be parallel to L; and the phase change for light travelling the length of the cavity is given from Eq.(1.64) by

$$\omega L/c' = \omega L/c(1 - \mathbf{c}\cdot\mathbf{v}/c^2). \tag{1.65}$$

Since $\mathbf{c}$, the velocity of energy propagation is not parallel to $\mathbf{c}'$; the qunatity $\mathbf{v}\cdot\mathbf{c}$ must be found in terms of $\mathbf{v}\cdot\mathbf{c}'$. From Eqs.(1.63), (1.64), and the fact that $\mathbf{c}' = L\mathbf{c}'/L$ it follows that

$$\mathbf{v}\cdot\mathbf{c}' = (\mathbf{v}\cdot L\mathbf{c}/L)(1 - \mathbf{v}\cdot\mathbf{c}/c^2) = \mathbf{v}\cdot\mathbf{c} - v^2. \tag{1.66}$$

Solving the last two members of Eq.(1.66) for $\mathbf{v}\cdot\mathbf{c}$ yields

$$\mathbf{v}\cdot\mathbf{c}/c^2 = (\mathbf{v}\cdot L/cL + v^2/c^2)/(1 + \mathbf{v}\cdot L/cL). \tag{1.67}$$

The phase change out along L from Eqs.(1.65) and (1.67) is then

$$\omega L/c' = (\omega L/c)(1 + \mathbf{v}\cdot L/cL)/(1 - v^2/c^2). \tag{1.68}$$

The phase change back along L is given by replacing L by - L. The total phase change out and back is then

$$2\omega L/c_c = 2\omega L/c(1 - v^2/c^2) \tag{1.69}$$

where $c_c$ is the effective out and back phase velocity, as given by Eq.(1.62), as was to be shown.

Considering the square of the absolute velocity of the observer

$$v^2 = (\mathbf{v}_s + \mathbf{v}_o + \mathbf{v}_r)^2 = v_s^2 + 2\mathbf{v}_s\cdot\mathbf{v}_o + v_o^2 + 2\mathbf{v}_s\cdot\mathbf{v}_r + 2\mathbf{v}_o\cdot\mathbf{v}_r + v_r^2, \tag{1.70}$$

where $\mathbf{v}_s$ is the absolute velocity of the solar system of about 300 km/s, $\mathbf{v}_o$ is the velocity of the Earth in orbit about the Sun of about 30 km/s, and $\mathbf{v}_r$ is the velocity of the Earth's surface due

to its rotation less than about 0.3 km/s. The terms involving $v_r$ in Eq.(1.70) are too small to be readily detected and may be neglected. The terms $(v_s^2 + v_o^2)$ are fixed and do not change with the day or year. The only term of interest, that changes with the year is

$$2\mathbf{v}_s \cdot \mathbf{v}_o / c^2. \tag{1.71}$$

This term varies with the order of magnitude $\pm 2 \times 10^{-7}$.

It is, thus, concluded that the component of the absolute velocity of the solar system in the plane of the ecliptic $v_{so}$ can be determined in magnitude and direction to perhaps a 2 place accuracy for $v_{so}/c$ from the annual variation in the cavity measurement of the phase velocity $c_c$, as given by Eq.(1.62), which involves the quantity given by Eq.(1.71). In particular, the annual change in the frequency $\nu$ for a cavity of fixed length L yields from Eqs.(1.62), (1.70), and (1.71)

$$\mathbf{v}_s \cdot \mathbf{v}_o / v_o c = (c/2v_o)\left(1 - (v_s^2 + v_o^2)/c^2 - 2L\,\nu/c\right). \tag{1.72}$$

When the frequency $\nu$ is a minimum $\mathbf{v}_s$ is parallel to $\mathbf{v}_o$; and the direction of $\mathbf{v}_o$ at this time of year is the direction of the component of $\mathbf{v}_{so}$ in the ecliptic. Six months later the observed frequency will be a maximum; and the magnitude of the component of the absolute velocity of the solar system in the plane of the ecliptic is given by

$$v_{so} = (cL/2v_o)\left[\nu(\max) - \nu(\min)\right]. \tag{1.73}$$

(It should be noted that the incorrect reported value of c appearing in tables, taken from cavity values that measure $c_c$, not c, Eq.(1.62), needs to be corrected upwards. From Eq.(1.62) $c = c_c/(1 - v^2/c^2) \simeq c_c(1 + v^2/c^2)$ and where $v^2/c^2 \simeq 10^{-6}$; so even apart from the annual variation the reported value needs to be increased in the 6th decimal place. The usual 9 places reported in the tables is, of course, an exaggeration of the accuracy that can be obtained. The last 3 digits are questionable.)

1.8f Proposed velocity of an electric signal down a wire to measure absolute velocity – It is generally recognized that the velocity of an electric signal down a wire is c. However, it is also accepted that the velocity of transmision of mass or energy



is limited to the absolute value c; so the velocity of a signal, carrying energy, down a *moving* wire cannot be c, but must be

$$c^* = c - \mathbf{v}\cdot\mathbf{n}, \tag{1.74}$$

where $\mathbf{n}$ is a unit vector in the direction of the wire and $\mathbf{v}$ is the absolute velocity of the wire (cf. Eq.(1.15)).

Considering the fixed time delay theory for the propagation of light in a moving medium (Hoek 1868, Kosowski 1978, Marinov 1977, and Wesley 1991c), it may be assumed that the velocity of a signal down a wire will also be delayed a small fixed amount, depending upon the amount of material the signal meets underway. Since only a comparison of the signal velocity in opposite directions along the same length of wire is of interest here; the effect of a fixed time delay cancels out and may be neglected.

The proposed experiment involves a wire segment of length L, rotated about its center with an angular velocity $\Omega$. A signal generator, that generates a sinusoidal signal,

$$y = A \sin \omega t, \tag{1.75}$$

where $\omega$ is the angular frequency of the signal, is fixed to one end and a receiver is fixed to the other end. Considering time retardation, the signal received is given by

$$y = A \sin \omega \left[t + L/(c - \mathbf{v}_p \cdot \mathbf{L}/L)\right], \tag{1.76}$$

where $\mathbf{v}_p$ is the component of the absolute velocity of the wire in the plane of rotation. The quantity $\mathbf{v}_p \cdot \mathbf{L}/L$ is given in the plane of rotation by

$$\mathbf{v}_p \cdot \mathbf{L}/L = v_p \cos(\Omega t - \Theta), \tag{1.77}$$

where the angle $\Omega t$ and the fixed angular position of $\mathbf{v}_p$ in the plane $\Theta$ are measured from some fixed direction in the laboratory, such as the eastward direction.

To extract the desired information concerning $\mathbf{v}_p$ it is necessary to approximate Eqs.(1.76) and (1.77) by considering the order of magnitude of the parameters involved: $v_p/c \simeq 10^{-3}$, $L \simeq 1$ m, $\Omega \simeq 2\pi \times 100$ Hz rad, $\omega \simeq 2\pi \times 10^8$ Hz rad, and $\omega L v_p/c^2 \simeq 2 \times 10^{-3}$. To first order in $v_p/c$ from Eqs.(1.76) and (1.77)

$$y = (A\omega L v_p/c^2) \cos\left[\omega(t + L/c)\right] \sin(\Omega t - \Theta). \tag{1.78}$$

Filtering out the rapid time variation $\omega t$, the root mean square value of y becomes

$$y = A/\sqrt{2} + A' \cos(\Omega t - \Theta), \tag{1.79}$$

where the small amplitude A' of the slowly varying signal is given by

$$A' = A\omega L v_p/\sqrt{2}c^2. \tag{1.80}$$

The magnitude of the absolute velocity of the wire in the plane of rotation is then given by

$$v_p/c = \sqrt{2}cA'/A\omega L, \tag{1.81}$$

which is of the order of magnitude $10^{-3}$, which should be readily detectable. The quantity $A/\sqrt{2}$ may be taken from the nonvarying portion of the signal, as given by Eq.(1.79).

The magnitude of the absolute velocity of the setup $|\mathbf{v}_s|$ is given when the plane of rotation is chosen so that $v_p$ is a maximum, and $\mathbf{v}_s$ lies in the plane of rotation,

$$|\mathbf{v}_s| = v_p(\max). \tag{1.82}$$

The direction of the absolute velocity $\mathbf{v}_s$ may be obtained, when the plane of rotation is chosen for $v_p$ a maximum, by putting the slowly varying signal on an oscilloscope and noting the direction of the wire L when the signal is a maximum, as indicated by Eq.(1.79). At this instant $\mathbf{v}_s$ is in the direction of L.

The direction of the absolute velocity $\mathbf{v}_s$ may also be noted as the normal to the plane of rotation when the slowly varying signal amplitude is zero, when $\mathbf{v}_p \cdot \mathbf{L} = \mathbf{v}_s \cdot \mathbf{L} = 0$. But the sense of the direction along the normal cannot be determined.

1.8g The permanent Bradley stellar aberration for the velocity of the solar system - Considering Fig. 1.1 where $\beta = \Theta - \Theta^*$, Eq.(1.18), Bradley stellar aberration yields

$$\sin(\Theta - \Theta^*) = (v/c)\sin\Theta^*, \tag{1.83}$$

where $\Theta$ and $\Theta^*$ are now measured from the permanent forward direction of the absolute velocity of the solar system, where $v = v_s$.

An actual element of solid angle on the celestial sphere, $d\Omega = \sin\Theta\, d\Theta\, d\phi$, as a function of the observed or apparent element



of solid angle, $d\Omega^* = \sin\Theta^* d\Theta^* d\phi$, may be obtained from Eq.(1.83) to first order in v/c as

$$d\Omega \simeq \left[1 + 2(v_s/c)\cos\Theta^*\right] d\Omega^*. \tag{1.84}$$

This result means that the surface number density of distant galaxies $\sigma = dN/d\Omega$, that is a constant $\sigma_o$ in a uniform universe, will appear nonisotropic to an observer moving with the absolute velocity $v_s$ due to the permanent Bradley aberration, where from Eq.(1.84) the apparent or observed density is given by

$$\sigma^* = \left[1 + 2(v_s/c)\cos\Theta^*\right] \sigma_o. \tag{1.85}$$

By observing the number density per unit solid angle of the most distant galaxies $\sigma^*$ as a function of direction the magnitude and direction of the absolute velocity of the solar system may be obtained from Eq.(1.85) as

$$\mathbf{v}_s \cdot \mathbf{n}/c = (\sigma^* - \sigma_o)/2\sigma_o, \tag{1.86}$$

where $\mathbf{n}$ is a unit vector in the direction of the telescope, and where $\sigma_o$ may be taken as the mean value over all directions. Both the direction and magnitude are given when $\mathbf{v}_s \cdot \mathbf{n} = v_s$ is a maximum.

Not only does the permanent Bradley aberration produce an apparent anisotropy in the density of distant galaxies; the amount of light per unit solid angle from the most distant galaxies should reveal the same anisotropy.

The permanent Bradley aberration due to the absolute velocity of the solar system, when ignored, produces a small error in classical celestial mechanics, that can be important when high precision is required. The permanent aberration, as given by Eqs.(1.83) and (1.84), produces an astigmatic view of the universe. The apparent positions of stars are not their true positions. In order to obtain the true position of a star a correction must be made (Wesley 1991e). From Eq.(1.83) the angular displacement of a stellar image from the true position, for $v/c \simeq 10^{-3}$ can be up to $\Theta - \Theta^* \simeq 10^{-3}$ radians.

Unfortunately, present-day astronomical observations are not corrected for this permanent aberration; so the reported motion of

the planets is not quite correct for the actual physical motion. The reported motion must, thus, differ slightly from the predictions using classical celestial mechanics. The famous very small unexplained portion of the precession of the perihelion of Mercury may, thus, be merely a consequence of the failure to correct for permanent Bradley aberration. Someone with access to the planetary data and the known value of $v_s$ should be able to determine whether or not this unexplained portion is, in fact, due to the permanent Bradley aberration or not.

1.8h Rotating polarizers to measure absolute velocity – The proposed setup is indicated in Fig. 1.10. Instead of toothed wheels

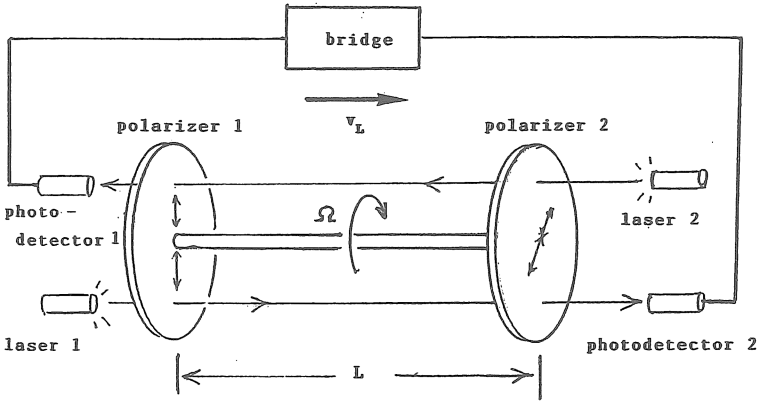



Fig. 1.10 Diagram of the rotating polarizers experiment to measure absolute velocity.

two sheet polarizers, as provided by polaroid film, can be used. This provides a steady output from the photodetectors; as no chopping of the light beams are involved. The intensity of light passing through both polarizers remains constant in time. It depends only upon the *relative* polarization angle between the two polarizers.



Alternatively, one can rotate the laser sources with the polarizers and photodetectors together; so there is no relative motion between any parts of the setup. In this way crystal polarizers can be used; and the photodetector outputs will agian remain constant in time.

When stationary the polarizers can be oriented with respect to each other at 45°. Taking into account the time it takes light to travel between the polarizers the distance L, the relative angle of polarization changes, using Eq.(1.15), by the amount

$$\Omega L/(c \mp v_L) \simeq \Omega L/c \pm \Omega L v_L/c^2 , \tag{1.87}$$

where $\Omega$ is the angular velocity of the polarizers and $v_L$ is the component of the absolute velocity of the setup in the direction from polarizer 1 to polarizer 2, as indicated in Fig. 1.10. The intensity of light passing through the two polarizers becomes from Eq.(1.87)

$$\begin{aligned} I &= I_o \cos^2(\pi/4 + \Omega L/c \pm \Omega L v_L/c^2) \\ &\simeq I_o \left\{ [1 - \sin(2\Omega L/c)]/2 \pm \cos(2\Omega L/c)(\Omega L v_L/c^2) \right\} , \end{aligned} \tag{1.88}$$

to first order in $\Omega L v_L/c^2$.

The difference in intensity of the light passing through the polarizers in opposite directions, which can be accurately measured in an electronic bridge, is given by

$$I_- - I_+ = 2I_o \cos(2\Omega L/c)(\Omega L v_L/c^2). \tag{1.89}$$

Neglecting $(2\Omega L/c)^2$ as small compared with unity, the desired component of the absolute velocity of the setup becomes

$$v_L/c = c(I_- - I_+)/2I_o \Omega L , \tag{1.90}$$

where all of the quantities on the right can be determined.

The setup indicated in Fig. 1.10 can be mounted on a horizontal turntable. By changing the direction L the component of the absolute velocity of the laboratory in the horizontal plane can be found. At a northern (or southern) latitude the orientation of the plane of the turntable changes during the day, which then permits the computation of the absolute velocity of the laboratory, the Earth, and the solar system in magnitude and in direction.

## 1.9 The 2.7°K Cosmic Background to Determine Absolute Space

It may be readily shown (Wesley 1996 and Chapter 2) that the light radiated by distant galaxies in an infinite uniform universe that is attenuated by the cosmological red shift yields the observed 2.7°K cosmic background radiation. This background was predicted before it was observed by Regener (1931) as the equilibrium temperature of a black body exposed to distant starlight in the night sky. To a first approximation this cosmic background is isotropic, as first observed by Penzias and Wilson (1965).

From the cosmological principle of a uniform universe in the large the 2.7°K cosmic background may be expected to be isotropic in the absolute rest frame. Thus, if an observer moves with an absolute velocity $v_s$ through this cosmic background, he will observe a greater flux of radiation in the forward direction and a decreased flux in the rearward direction. The observed anisotropy in the 2.7°K cosmic background can then be used to determine the absolute velocity of the observer. The temperature of a bolometer in equilibrium with the background radiation incident from a particular direction can be used to measure the radiant energy flux received in this direction from the fourth power law for radiation. Thus, from Eq.(1.15) and the fourth power law the deviation $\delta T$ from the mean temperature T yields

$$\delta T/T = \delta I/4I = (v_s/c)\cos\Theta_s, \tag{1.91}$$

where $\Theta_s$ is measured from the forward direction of the absolute velocity of the observer.

Conklin (1964) was the first to measure this small anisotropy of the cosmic background, Eq.(1.91), from the ground. He thereby estimated an absolute velocity for the observer or solar system as $v_s = 200 \pm 100$ km/s, $\alpha_s = 13 \pm 2^h$, and $\delta_s = 30 \pm 30°$. Henry (1971) obtained the best value of $v_s$ by this method by observing the anisotropy from a balloon, obtaining $v_s = 320 \pm 80$ km/s, $\alpha_s = 10 \pm 4^h$, and $\delta_s = -30 \pm 25°$. Others observing this anisotropy have obtained similar results.



Others, observing this anisotropy, have obtained similar results, such as Smoot et al in 1977, making observations from an airplane, obtained the values $v_s = 390 \pm 60$ km/s, $\alpha_s = 11.0 \pm 0.5^h$, and $\delta_s = 5 \pm 10°$. It should be possible to make observations from the space station in outer space, free from all atmospheric effects and with sufficient time to sample the entire sky adequately, to obtain really accurate results.

The observations of the 2.7°K background anisotropy yielded for the first time a reliable estimate of the absolute velocity of the solar system. And for the first time an explicit numerical estimate of the *absolute* velocity of a body in the laboratory could be given. The 2.7°K cosmic background radiation provides overwhelming evidence for absolute space and the existence of unique absolute velocities relative to this preferred absolute zero-velocity rest frame.

## 1.10 Mass-Energy Equivalence Implies Absolute Space

Mass-energy equivalence,

$$E = c^2 m, \tag{1.92}$$

is firmly empirically established by the observations in nuclear and particle physics. Accepting this principle to mean any form of energy, then there must be a mass equivalent for kinetic energy as well. This means that Newtonian mechanics must be modified to include this fact. The new modified mechanics compatible with mass-energy equivalence is called "neomechanics", which is valid in absolute space and time. (The term "neomechanics" has been chosen to avoid confusion with "special relativity" and all of its empirically impossible space-time nonsense (e.g., Galeczki and Marquardt (1997))

If the mass equivalent of the kinetic energy K is $K/c^2$, then the momentum of a body with the material mass m must be given by

$$p = (m + K/c^2)v. \tag{1.93}$$

From Newton's second law the rate work is done on a body equals the time rate of increase of the kinetic energy; thus,

$$\mathbf{v}\cdot d\mathbf{p}/dt = \mathbf{v}\cdot d\left[(m + K/c^2)\mathbf{v}\right]/dt = dK/dt. \qquad (1.94)$$

Integrating the last two members of Eq.(1.94) and choosing the constant of integration so that K = 0 when v = 0 yields the kinetic energy

$$K = c^2 m(\gamma - 1), \qquad (1.95)$$

where

$$\gamma = 1/\sqrt{1 - v^2/c^2}. \qquad (1.96)$$

Substituting Eq.(1.95) into Eq.(1.93) then yields the neomechanical momentum as

$$\mathbf{p} = m\gamma\mathbf{v}. \qquad (1.97)$$

Newton's second law for the inertial force is then a function of the velocity as well as the acceleration of a body; thus,

$$\mathbf{F} = d\mathbf{p}/dt = d(m\gamma\mathbf{v})/dt. \qquad (1.98)$$

In order for all of the dynamical properties of a body to be precisely uniquely specified the absolute velocity v, as well as the absolute acceleration a must be used in Newton's second law, Eq.(1.98). A relative velocity or a relative acceleration, depending upon any arbitrary reference frame, and thus not uniquely defined, is not admissible! Neomechanics is thus clearly precisely valid only when referred to absolute space. Consequently it is concluded that mass-energy equivalence implies the existence of absolute space.

It is important to note that only the $\gamma$ factor distinguishes neomechanics from Newtonian mechanics. Thus, absolute velocities become important only for larger values of $v^2/c^2$. Ordinarily $v^2/c^2$ is so small that Newtonian mechanics suffices; and absolute velocities are not needed.

When velocities are large and the $\gamma$ factor is greater than unity there is the opportunity to measure the absolute velocity of a body, which includes the velocity of the laboratory, the Earth, and the solar system. Thus, energetic particle accelerators, producing fast particles, provide the opporunity to measure the absolute velocity of the solar system by measuring the time of flight velocity of the particles as a function of absolute direction



for a known specific energy. The first utilization of fast particles to thus measure the absolute velocity of the solar system is presented in the following Section.

## 1.11 Cosmic-Ray Muon Flux Anisotropy for the Absolute Velocity of the Solar System

Monstein and Wesley (1996) measured the flux of cosmic-ray muons as a function of their direction of arrival to obtain the absolute velocity of the solar system. In particular, the flux of muons S, that are created high in the atmosphere at about 16 km altitude h above the Earth from pions and arrive at ground level, depends upon the number that have survived radioactive decay into electrons and neutrinos. The half-life for stationary muons is $\tau_o = 2.22 \times 10^{-6}$ s. But the half-life for fast moving radioactive particles is found to be greater (Bailey et al 1977) and to be given by

$$\tau = \tau_o\gamma = \tau_o/\sqrt{1 - v^2/c^2}\ , \qquad (1.99)$$

where v is the *absolute* velocity of the particle. It has been shown (Wesley 1991f) that this effect, Eq.(1.99), is a statistical neomechanical effect, the phase space available for daughter particles from a fast moving radioactive parent particle being decreased by the factor $1/\gamma$. It has been recognized since the early days of cosmic ray research that the unexpectedly large ground level flux S of muons is due to their increased half-life as given by the $\gamma$ factor in Eq.(1.99) and the muon's high velocity.

The gamma factor in Eq.(1.99), depending upon the *absolute* velocity of the muon, depends upon the *absolute* velocity of the solar system. Neglecting the small velocity of the Earth's surface due to rotation, which is less than about 0.3 km/s and also neglecting the velocity of the Earth in orbit about the Sun, which is about 30 km/s, the muon's *absolute* velocity becomes

$$v^2 = (\mathbf{v}' + \mathbf{v}_s)^2 = v'^2 + 2\mathbf{v}'\cdot\mathbf{v}_s + v_s^2 \simeq v'^2 + 2\mathbf{n}\cdot\mathbf{v}_s v', \qquad (1.100)$$

where $\mathbf{v}_s$ is the *absolute* velocity of the solar system, $\mathbf{v}'$ is the velocity of the muon relative to the Earth or cosmic-ray telescope, n is a unit vector in the direction of arrival of the muon or the

cosmic-ray telescope, and where $v_s^2/v'^2 \simeq 10^{-6}$ (as $v' \simeq c$) has been neglected.

The fraction of muons arriving at ground level due to radioactive decay is given by

$$S/S' = \exp(-t/\tau) = \exp(-D/\tau_o \gamma v'), \tag{1.101}$$

where D is the distance the muon travels to reach the ground with the velocity $v'$ in the time t, and $S'$ is the flux where the muons are created. The distance D is the slant height that the muon must travel to reach the telescope, which is mounted in a meridial plane to sample the sky at different declinations $\delta$ ; so

$$D = h/\cos(\delta - \delta_e), \tag{1.102}$$

where $\delta_e$ is the latitude of the observatory and h is the altitude where the muon is created.

The anisotropy of the muon flux of interest is given by the scalar product $\mathbf{n}\cdot\mathbf{v}_s v'$ in Eq.(1.100). Since $v'$ is approximately c and $v_s/c$ is approximately $10^{-3}$ , the quantity

$$\xi = \mathbf{n}\cdot\mathbf{v}_s v'/c^2 , \tag{1.103}$$

may be regarded as a small quantity as compared with $v'^2/c^2$. The flux S may then be expanded to first order in this quantity $\xi$ ;

$$S = S_o + (dS/d\xi)_o(\mathbf{n}\cdot\mathbf{v}_s v')/c^2. \tag{1.104}$$

Differentiating Eq.(1.97), where $1/\gamma = \sqrt{1 - v'^2/c^2 - 2\xi}$ , yields

$$dS/d\xi = S h\gamma/\tau_o v' \cos(\delta - \delta), \tag{1.105}$$

which is to be evaluated for $\xi = \mathbf{n}\cdot\mathbf{v}_s v'/c^2 = 0$ and $v = v_s = v'$. The quantity $S_o$ equal to S for $\xi = 0$ may be taken as the observed flux S averaged over all directions; since averaging $\mathbf{n}\cdot\mathbf{v}_s$ over all directions yields zero.

The desired result from Eqs.(1.105) and (1.104) is then

$$\mathbf{n}\cdot\mathbf{v}_s/c = K\cos(\delta - \delta_e')\left[(\bar{S} - \bar{S})/\bar{S}\right], \tag{1.106}$$

where $\bar{S}$ is the average observed flux over all directions and K is a constant given by

$$K = c\,\tau_o/\gamma h, \tag{1.107}$$

where the $\gamma$ here is a constant appropriately estimated from the



known kinetic energy of cosmic-ray muons, which may be roughly estimated to yield $\gamma = 2.7$. Since muons are created at different heights with different energies only rough mean estimates can be made. In this way the constant K was estimated to have the value K = 0.016 with perhaps an uncertainty of 20 percent.

The angle of right ascension $\alpha$ for the incident muons was given by the time of day and date. The angle of declination $\delta$ was sampled each day in a meridian plane. The whole available sky was thereby sampled by an automated setup over an 18 year period involving 3600 days and 32,369 coincident counts between counters in the cosmic-ray telescope. With this accumulated data the velocity of the solar system $v_s$ was found to be: $v_s = 360 \pm 100$ km/s, $\alpha_s = 8.7 \pm 3.5^h$, and $\delta_s = -1.1 \pm 10.0°$.

Since the value of the absolute velocity of the solar system obtained by this method. although not precise, is in agreement with the value obtained by other independent methods; it constitutes further empirical proof for the existence of absolute space.

In addition, it is important to note that this result confirms empirically *for the first time* the fact that the velocity in the $\gamma$ factor must be the *absolute* velocity and not some arbitrary *relative* velocity. This result is, thus, evidence for neomechanics. (Neomechanics is clearly compatible with Newtonian mechanics. In contrast, "special relativity", denying the very existence of *absolute space-time*, is clearly not compatible with Newtonian mechanics, that requires *absolute space-time*, as indicated above. The variation of mass with velocity, given by the formula $m = m_o\gamma$ , (that was empirically established before the advent of "special relativity") appears superficially to be precisely the same formula in neomechanics as in "special relativity"; but this is, in fact, not true. In "special relativity" the velocity v in the $\gamma$ factor is supposed to be *a relative velocity* for the mass $m_o$, that depends upon some arbitrarily chosen coordinate system. In contrast, in neomechanics the velocity v appearing in the $\gamma$ factor must be the unique *absolute velocity* of the mass $m_o$; so the formula is unique and not arbitrary. In general neomechanics can provide unique answers; whereas "special relativity" is necessarily ambiguous.)

Table 1.1 Values of the absolute velocity of the solar system

| method | observer | year | $v_s$ km/s | $\alpha_s$ hour | $\delta_s$ deg. |
|---|---|---|---|---|---|
| galactic red shifts | Hubble | 1939 | 300 | 3.3 | 55 |
| | de Vaucouleurs and Peters | 1968 | 300 ± 50 | 7 ± 1 | 50 ± 10 |
| | Rubins et al | 1976 | 600 ± 100 | 2 ± 2 | 50 ± 20 |
| 2.7°K background anisotropy | | | | | |
| from ground | Conklin | 1964 | 200 ± 100 | 13 ± 2 | 30 ± 30 |
| from balloon | Henry | 1971 | 320 ± 80 | 10 ± 4 | −30 ± 25 |
| from airplane | Smoot et al | 1977 | 390 ± 60 | 11.0 ± 0.5 | 5 ± 10 |
| anisotropy of light velocity | | | | | |
| coupled mirrors | Marinov | 1974 | 300 ± 20 | 13.3 ± 0.3 | −20 ± 4 |
| toothed wheels | Marinov | 1980 | 360 ± 40 | 12 ± 1 | −24 ± 7 |
| geostationary satellite signals | Müller and Means | 1994 | 250 ± 50 | 6 ± 1 | −14 ± 3 |
| muon flux anisotropy | Monstein and Wesley | 1996 | 360 ± 100 | 9 ± 4 | − 1 ± 10 |

CHAPTER 2

# COSMOLOGY IN A NONEXPANDING UNIVERSE

Many serious scientists have examined the evidence and have concluded that the universe is not expanding, for example: Galeczki and Marquardt (1996a), Drew (1997), Edwards (1998), Hubble (1936), Assis (1992, 1993), Jaakkola (1996), Kropotkin (1991), La Violette (1986), Marmet (1991), Monti (1987), Múnera (1998), Mészaros (1996), Narlikar & Arp(1993), Arp (1998), Nernst (1937), Phipps (1989), Troitskij (1996), Van Flandern (1996), Ward (1961), Zwicky (1929), and Wesley (1968, 1988, 1991g, 1996a, 1998g). It would, thus, seem that this paper, presenting the same conclusion, is unnecessary. However, the struggle against pseudoscience, such as the so-called "standard model of the universe" (e.g., Weinberg 1972) needs to be continued. The "standard model" is currently even presented to students in beginning astronomy textbooks as "cosmology" (e.g., Karttunen et al 1994).

In addition, the interpretation of the evidence can be again profitably reviewed. Certain aspects have not been sufficiently stressed or have been overlooked. The evidence can only be properly scientifically evaluated using only those principles that have been rigorously empirically established. Ad hoc ideas that can explain only one thing, such as an expanding universe to explain only the cosmological red shift as a Doppler shift, are not admissible.

It has not been properly appreciated that an expansion of the universe in a Euclidean space (the only space empirically established) to account for the cosmological red shift is necessarily an accelerating expansion. The energy necessary to perpetually increase the kinetic energy of all the masses in the universe is just not available.

The cosmological red shift can be explained as a gravitational drag, a mechanism that has been observed and verified in the laboratory (Pound and Rebka 1960).

The steady-state nonexpanding universe is perpetually rejuvenated when the high entropy energy of thermal photons of low utility is converted to gravitational potential energy of maximum unit utility. The gravitational drag, that produces this conversion, also produces the cosmological red shift and a dilation of local mass density.

## 2.1 Special and General Relativity Are Rejected

Having never gained complete acceptance, special relativity has been demonstrated many times to fail in many different ways (de Bothezat 1936; Essen 1978, 1988; Galeczki and Marquardt 1996b, 1997; Galeczki 1996; Marinov and Wesley eds. 1982; Monti 1996; Theimer 1972; Wesley 1983, 1986. 1987, 1989a, 1991h, 1996b, 1998a). In addition to the failures indicated by the "twin paradox" and the fact that the observed oneway velocity of light $c^*$ depends upon the absolute velocity of the observer $v$, such that $c^* = c - v$ (Roemer 1677; Halley 1694; Bradley 1728; Marinov 1974, 1980), that contradicts one of the three "axioms" of special relativity, special relativity fails along with the Lorentz covariant Maxwell electromagnetic theory, that fails many experimental tests (Wesley 1990, 1991i, 1998b, 1998c; Chapters 4, 5, and 10 below; Phipps 1998).

General relativity is likewise rejected. In the weak gravitational field limit it yields special relativity; so general relativity necessarily fails along with special relativity. Moreover, it also fails in many additional ways, as discussed in the excellent paper by Galeczki and Marquardt (1996a) (also Galeczki 1999). Its Schwarzschild singularity in empty space, violates the requirement that no observable quantity can, in fact, be infinite. Its *postulate* that gravitational and accelerated frames are *equivalent* is false; because inertial and gravitational forces are readily distinguished from each other. General relativity cannot conserve mass-energy; because the postulated source of the gravitational field, the stress energy tensor involves only the material mass and does not include the necessary mass equivalent of the gravitational field energy itself. A gravitational theory conserving mass-energy, where the necessary mass equivalent of the gravitational field energy itself is included as part of the source of the gravitational field has been developed by the author (Wesley 1988, Chapter 3 below).



There is no local empirical evidence for curved space. Thus, curved space on a cosmic scale, that cannot be empirically established, is merely idle speculation that must be rejected.

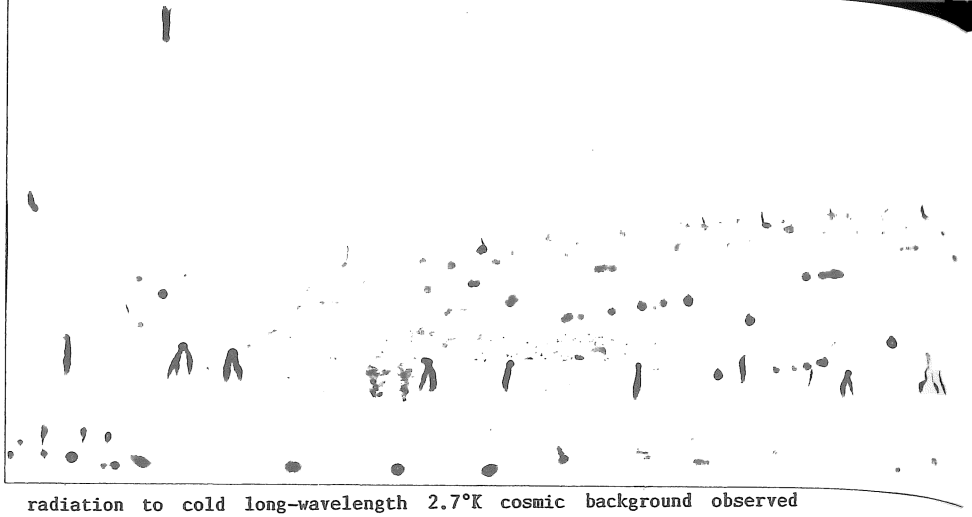
The only real empirical evidence ever suggested in support of general relativity is supposedly the prediction of the small very uncertain additional (beyond classical Newtonian theory) bending of starlight around the Sun and the very small and uncertain unexplained portion (beyond Newtonian theory) of the precessiom of the perihelion of Mercury. This suggested evidence, representing only two uncertain data points, is far too meagre for any theory to be taken seriously. Moreover, there are alternative more reasonable explanations for these effects.

The small additional bending of starlight around the sun beyond that predicted by Newtonian theory might be explained as simply a particular feature of the optical characteristics of the solar corona. The necessary reasonable extension of Newtonian gravitation to include the mass equivalent of the gravitational field energy itself by Wesley (1988, Section 3.16 below) predicts the observed bending.

The more physically reasonable Weber-type gravitational theory predicted the unexplained portion of the precession of the perihelion of Mercury more than 40 years before the advent of general relativity (Tisserand 1872, 1895; Gerber 1898; Schroedinger 1925; Assis 1989). Moreover, the parameters for the orbits of the planets have not been corrected for the astigmatic view of the universe produced by Bradley aberration due to the absolute velocity of the solar system (Wesley 1991e); so when the corrected parameters are used there may be no "unexplained portion" of the precession of the perihelion of Mercury.

## 2.2 The Universe Appears Uniform and Nonexpanding

The universe viewed in-the-large, beyond our local group of galaxies, appears to satisfy the cosmological principle, that says the universe is uniform and isotropic in-the-large and that it will appear the same from any point in space. Each type of galaxy appears to be uniformly distributed throughout the observable universe. As ever newer and more powerful telescopes look farther and farther into space the uniformity of the universe is revealed out to at least



radiation to cold long-wavelength 2.7°K cosmic background observed today. Thus, the embarrassing physical problem of how the energy of the big bang radiation was lost to yield 2.7°K radiation is converted to a pseudo-kinematics. The idea of "curved space" is of this nature, no actual observations being necessary to *define* it.

If the universe were expanding, then extrapolating far enough back into time in an absolute Euclidean space, it should have originated at a point with a big bang. If the entire universe had originated at a *finite* time in the past at a point, there should certainly be some obvious evidence today of where such a cataclysmic event occurred. But no such unique point is seen in the universe today. The universe cannot be expanding.

It would also be expected from chaos theory that inevitable infinitesimal fluctuations in density and velocity in the early universe should have given rise to subsequent large scale hydrodynamic turbulence and streaming of the order of the size of the finite universe itself. But no such grand scale turbulence or streaming is seen in the universe today. The universe cannot be expanding.

If the universe were expanding, then, as one looks farther out into space and thus farther back into time, one should expect to see a greater density of galaxies characteristic of a less expanded universe; but no such greater density of galaxies with distance is seen.

Since an expanding universe must be finite in an absolute Euclidean space; one might expect to see its outer boundary as one looks far enough into space, if the universe is, in fact, expanding. Or one might expect to see far enough back into time to see the



exploding big bang itself at some unique point in the sky. But no such boundary to the universe or big bang has been seen. There is, thus, no such direct evidence that the universe is expanding.

On a cosmic scale of $10^8$ light years the universe exhibits a *single* nonuniform feature, that has been interpreted to mean that the universe is expanding. Namely, light from distant galaxies with the spectral signature characteristic of an element is observed to be shifted toward the red as a function of the distance of the source galaxy from the Earth, the cosmological red shift. However, instead of attempting (unsuccessfully) to explain this *single* phenomenon as due to a grandiose expanding of the whole universe, it is better to explain it as merely an extraneous "tired light" effect on light travelling through the universe, as discussed in detail in Sections 2.6 through 2.8 below.

## 2.3. The Universe Is in Steady-State Equilibrium

It needs to be remarked that the universe, although uniform and static in-the-large, is obviously neither uniform nor static locally within our Milky Way Galaxy over times of the order of $4.5 \times 10^9$ years. "Locally" the time from the formation of certain minerals, or the age of the mineral, can be measured; and ages of $10^9$ years found. The uniform expansion rate of large globular clusters of stars in the Galactic halo, as determined by their differential red shifts, yield the time from the origin at a single point of about $18 \times 10^9$ years. Fossils on the Earth provide evidence of an evolutionary change of life over the last $2 \times 10^9$ years.

To explain both the observed over-all uniform static character of the universe in-the-large as well as the local nonuniform and nonstatic character of the universe on a local galactic scale it is necessary to assume that the universe as a whole is in some sort of steady-state equilibrium with fluctuations on a local galactic scale of the order of $5 \times 10^9$ years. Steady-state cosmologies have been proposed by many researchers (Arp 1987, 1998; Assis 1993; Edwards 1998; Galeczki and Marquardt 1996a; Jaakkola 1996; Kropotkin 1991; Mac Millan 1918; Monti 1987; Nernst 1937; Phipps 1989; Troitskij 1996; Wesley 1991g, 1996a). Thus, local secular variations within

the Galaxy do not present evidence for any over-all secular variation in the universe as a whole, such as required by an expanding universe.

## 2.4 There Can Be No Rigorous Evidence for an Expanding Universe Nor for a Big Bang

Science is based upon the fundamental principle that physical laws, describing nature, were valid in the past, are valid now, and will be valid in the future, and that these laws are valid throughout the universe. This fundamental principle concerning the universality of physical laws in space and time, thus, implies an implicit faith that the universe was the same in the past, as now, and as it will be in the future, and that the universe in-the-large is uniform throughout. A static uniform nonexpanding universe is clearly compatible with this fundamental principle.

In contrast, the idea of an expanding universe, that violates this fundamental principle, is immediately faced with insurmountable difficulties. Extrapolating an expansion back in time, the universe had to have a *beginning* at some unique point in space and time. It



Gamov (1956) originally proposed his big bang to try to account for the relative abundances of the various elements that are assumed to exist in the universe today. Despite the unlimited freedom to make arbitrary assumptions, it is generally accepted today that the relative abundances of the elements is better accounted for by the nuclear processes in stars and novas (Lerner 1989).

## 2.5 A Big Bang with the Mass of the Universe Would Have Vanished into Its Own Black Hole

A big bang could never have happened; because, if all of the mass-energy of the universe had been confined to a local region of space, then it would have created such a huge gravitational attraction that the nascent universe would have simply disappeared forever by falling into its own gravitational hole. Such a huge concentration of mass-energy, or super black hole, could only contract and could never explode as a big bang to give rise to an expanding universe.

The Chandrasekhar (1939) general relativity limit prescribes a few solar masses as the maximum mass for any body in the universe. A similar limited size for mass concentrations of bodies is predicted using Newtonian gravitation and mass-energy equivalence. Thus, current gravitation theories preclude the possibility of black holes and a mass concentration that could give rise to a big bang and an expanding universe. (The author's (Wesley 1988, 1991i) own necessary gravitation theory permits super massive bodies; but it is based upon a nonexpanding universe. See the following Chapter 3.)

## 2.6 Absolute Space Precludes an Expanding Universe

As discussed in Chapter 1, there is a preferred nonaccelerating zero velocity frame of reference, that is stationary, unique, and valid throughout the entire universe. This "absolute space" can be determined at any point in the universe by using appropriate experimental observations. It is a space defined by physical properties. For example, the absolute zero velocity rest frame, or absolute space, is defined by the frame in which the all pervading 2.7°K cosmic background is isotropic (Conklin 1969; Henry

1971; and others).

Since an absolute stationary frame can be defined everywhere in the universe; a large portion of the universe cannot have a large general nonzero velocity relative to the rest of the universe, as required by an expanding universe. The existence of absolute space, that is empirically established, is thus clear empirical evidence that the universe is not expanding.

## 2.7 Some Tired Light Theories Proposed to Explain the Cosmological Red Shift

The only apparent nonuniform feature of the universe in-the-large is provided by the cosmological red shift. Spectral lines characterizing an element are observed to be fractionally red shifted roughly as the distance of the source from the Earth. Hubble's (1931) empirical law for the fractional frequency or energy decrease is

$$-\Delta\nu/\nu = \Delta E/E = Hs/c, \tag{2.1}$$

where s is the distance from the source to the Earth and H is the Hubble constant, estimated to lie between 50 to 100 km/sMpsc. The traditional $z = \Delta\lambda/\lambda = -(\Delta\nu/\nu)/(1 - \Delta\nu/\nu)$ represents no physics.

A "tired light" theory explains the cosmological red shift as simply an energy loss for light as it travels through the nonexpanding universe. These theories generally postulate some sort of ad hoc mechanism that is not substantiated by any other empirical evidence. According to Arp (1998b) mass increases with cosmological age; so more distant galaxies, existing earlier, have electrons with less mass, that produce less energetic red shifted spectra. (This idea fits his observations of two point quasars of high red shift on a line on opposite sides of a large active central galaxy of lesser red shift. These observations might also be accounted for without any mass increase with cosmological time. A collision of two super massive bodies, or a near meeting, could release matter to form the central galaxiy; and then they could pass on as visible objects, having lost sufficient matter to reduce their gravitational fields, thereby permitting the escape of radiation (Wesley 1969, 1991j). The different red shifts are then merely due to different gravitational attractions.) Van Flandern (1995), Edwards (1998), and Jaakkola (1989, 1993, 1996)



believe that ad hoc "gravitons", that are suppose to be responsible for the gravitational force of attraction, interact with photons to absorb their energy as a function of the distance they travel. Drew (1997) thinks there is an increase in clock rates with cosmic time; so the frequency of light radiated in the past from distant galaxies is now viewed as smaller than the light radiated today. Ghosh (1991) proposes a Weber-type gravitational theory that produces an induction drag on photons as they pass through the nonexpanding universe. But he does not explain where the dissipated energy goes. Huber (1994) has proposed the idea that gravity produces a drag on the velocity of light, thereby producing an apparent red shift. But no such drastic altered light velocity has been observed for distant starlight. According to Kipper (1974) an ether, consisting of electromagnetic oscillators, absorbs light energy to produce the cosmological red shift. Marmet (1991) and Mũnera (1998) think that atoms in intergalactic space absorb the energy. Monti (1987) and Nernst (1937) believe an ether with conductivity that attenuates light produces the cosmological red shift.

It is not clear just how much spreading of a light beam might be expected from these various proposed tired light mechanisms. The red shifted light observed from distant sources does not appear to be scattered at all.

These tired light theories are generally insufficient; because they do not adequately treat the problem of where the energy taken from the photons goes. The conservation of energy is generally thus neglected. The role the gravitational red shift might play in the rejuvenation of a steady-state nonexpanding universe is also generally neglected.

Generally the proposed tired light mechanisms are not confirmed by any laboratory experiments.

Hubble (1936) and Troitskij (1996) feel the cosmological red shift is produced by some mechanism that is still unknown.

## 2.8 A Gravitational Drag to Explain the Cosmological Red Shift

The most likely "tired light" mechanism is a gravitational drag. The masses in the universe that can increase their gravitational

energy are already present; so no hypothetical ether or exotic ad hoc mechanism need be postulated.

Zwicky (1929) was the first to consider a gravitational drag to explain the cosmological red shift in a static uniform nonexpanding universe. It has been subsequently proposed by others (Ferrari 1984; Galeczki and Marquardt 1996a; Kropotkin 1991; Wesley 1996a).

The coupling of a photon to a gravitational field that determines the photon's energy has been demonstrated by Pound and Rebka (1960) in the laboratory using the Mossbauer effect. They found that a photon travelling a height s upwards in the Earth's gravitational field with an acceleration of gravity g loses energy. The mass equivalent of a photon in flight equals its energy $h\nu$ divided by $c^2$; so the photon energy loss equals the increase in the gravitational potential energy gained; thus,

$$- h\Delta\nu = h\nu gs/c^2 , \tag{2.2}$$

The fractional gravitational red shift, as observed, is then

$$\Delta\nu/\nu = - gs/c^2 = - \Delta\ddot{U}/c^2. \tag{2.3}$$

where $\ddot{U}$ is the gravitational potential energy.

Since the amount of the red shift is different for different heights from the same starting level; a photon must lose its energy while in flight through the gravitational field. Considering Newton's third law, the Pound-Rebka experiment not only produces an effect on the photon in flight, it must also produce an infinitesimal effect on the Earth to which it is gravitationally coupled. The energy lost by the photon in flight must be transferred to the Earth. After the photon is absorbed, the net effect is an infinitesimal increase in the gravitational potential energy of the Earth due to the outward transfer of mass the height s. This outward transfer of mass also constitutes an infinitesimal decrease in the density of the Earth (See Section 3.14).

With this firm laboratory knowledge it is possible to envision the cosmological red shift as a gravitational drag. As a photon passes through the universe it is gravitationally coupled to all of the matter in the neighborhood of its path. The matter in the wake of the photon, having absorbed an infinitesimal amount of its energy, increases its gravitational potential energy by an infinitesimal local



dilation or expansion.

The gravitational drag mechanism also accounts for a depletion of neutrinos; since the gravitational coupling is only a function of the mass equivalent of the neutrino energy. In the absence of any other mechanism to balance the number of neutrinos introducded into the universe with the number absorbed the gravitational drag mechanism becomes important for a steady-state nonexpanding universe.

The gravitational drag phenomenon is also important in rejuvenating the steady-state nonexpanding universe, as discussed below in Section 12.

Wesley (1988) gravitation, presented in the following Chapter 3, predicts a gravitational drag with a numerical value for the cosmological red shift in agreement with the estimated observed value of Hubble's constant H. Wesley gravitation is based upon a necessary extension of Newtonian gravitation to include the mass equivalent of the gravitational field energy; thus.

$$\rho(\text{field}) = - (\nabla\Phi)^2/4\pi c^2 G. \tag{2.4}$$

The theory predicts effects slightly less than those given by the Newtonian inverse square law. In particular, from Eq.(3.71) a photon passing through a universe of uniform density $\rho$ experiences a fractional energy loss $\Delta\nu/\nu$ proportional to the distance travelled $\Delta r$; thus,

$$\Delta\nu/\nu = - \beta\Delta r = - H\Delta r/c, \tag{2.5}$$

where from Eq.(3.19), $c\beta = \sqrt{4\pi G\rho}$ = 71 km/sMpsec, in agreement with uncertain estimates of H from observations and the uncertain value of the density of the universe of $\rho = 10^{-29}$ gm/cm$^3$. This result (2.4) is a necessary natural consequence of Wesley gravitation; no ad hoc assumptions or parameters are involved. It would thus seem that the cosmological red shift is, in fact, due to a gravitational drag.

## 2.9 The Cosmological Red Shift Cannot Be a Doppler Shift Produced by an Expanding Universe

If the cosmological red shift, Eq.(2.1), were due to a Doppler shift produced by an expanding universe, then any two points separated

by the distance s would have to be receding from each other with a velocity $v_s$ given by

$$-\Delta\nu/\nu = v_s/c = Hs/c. \tag{2.6}$$

Kinematically the only possible way to satisfy Eq.(2.6) in absolute Euclidean space is for the universe to be expanding with a radial velocity from some unique origin given by

$$v_r(\text{expansion}) = Hr, \tag{2.7}$$

where r is the distance from the center of expansion.

To prove that Eq.(2.7) is necessary if Eq.(2.6) were true the vector distance between any two points r and r' may be considered, where $s = r - r'$. The relative velocity between points r and r' with individual radial velocities v and v' of expansion prescribed by Eq.(2.7) is then

$$v_r = v - v' = H(r - r') = Hs, \tag{2.8}$$

which is seen to yield Eq.(2.6) for the magnitudes of the vectors.

Since the expanding universe is necessarily expanding radially to yield the cosmological red shift as a Doppler shift; it must necessarily violate the cosmological principle. The outward flow of matter defines a preferred radial direction at every point in the universe. The expansion would define a unique origin for the universe. Since absolute velocities can be observed (as discussed above); the outward radial velocity of expansion should be seen as nonisotropic and nonuniform. Since no such grand scale violation of the cosmological principle is observed; an expanding universe to account for the cosmoloigcal red shift as a Doppler shift is impossible.

Integrating Eq.(2.7) the position of a body that defines and moves with the expansion is given as a function of time by

$$r = r_o \exp(Ht), \tag{2.9}$$

where $r_o$ is some initial position when $t = 0$. Since, according to Eq.(2.6), the rate of expansion is the same in all three dimensions; an element of volume $ds^3$, containing a fixed amount of mass dm, moving outward with the expansion, increases with time as exp(3Ht). The density of matter streaming outward with the expansion then



decreases with time according to

$$dm/ds^3 = \rho = \rho_o \exp(-3Ht), \tag{2.10}$$

Eliminating t between Eqs.(2.9) and (2.10), the density of matter in the expanding universe at any instant decreases as the third power of the distance from the center of the expansion; thus.

$$\rho = \rho_o r_o^3/r^3. \tag{2.11}$$

Such a rapidly changing density of galaxies, marking the absolute Euclidean space, with distance from a unique origin should provide a striking feature of the universe. Since no such nonuniformity in galactic densities is observed the universe cannot be expanding.

The expanding universe idea also requires an outward acceleration of stars and galaxies. Differentiating Eq.(2.7) yields

$$a_r = dv_r/dt = Hv_r = H^2r. \tag{2.12}$$

This acceleration increases linearly with the distance from the center of the universe.

This outward acceleration, Eq.(2.12), means that a force is needed to produce this acceleration of the mass of the universe, given per unit mass by

$$dF_r/dm = a_r = H^2r, \tag{2.13}$$

which also increases with the radial distance r. The rate that this force must do work to increase the kinetic energy of expansion per unit mass is given by

$$d^2E/dtdm = v_r dF_r/dm = H^2r^2, \tag{2.14}$$

which increases as the square of the radial distance. For some mean radial position of $2 \times 10^9$ light years and a Hubble constant of 71 km/sMpsc the rate of energy expenditure per gram is

$$d^2E/dtdm = 10^2 \text{ erg/sgm}, \tag{2.15}$$

which represents a vast rate of energy input to sustain the expansion, However, there can be no such force, Eq.(2.13), nor source of energy, as required by Eq,(2.14). Moreover the drastic changes with time and radial distance for the physical properties, given by Eqs.(2.7) and (2.10) through (2.14), indicate the complete impossibility of an expanding universe to explain the cosmological red shift as a Doppler

shift.

In addition, it may be shown that there would have to be an outward force and an energy source of the same order of magnitude for the universe to expand against the inward force due to its gravitational attraction; and no such outward force or energy source exists.

The expansion given by Eq.(2.7) may also be seen to be physically impossible from the known nature of explosions and expansions into empty space, such as occur in stellar novas. Once a fire ball has expanded sufficiently so that molecular collisions are no longer significant and it is transparent to light, a free expansion occurs. In a free expansion each molecule, photon, particle, and body moves out independently, each with its own initial velocity. In such a free expansion into empty space the radial velocities of the particles and bodies with mass decrease with the radial distance r due to the action of gravity; they do not increase their velocity with the radial distance, as required by Eq.(2.7). Thus a universe expanding into empty space, given by Eq.(2.7), to account for the cosmological red shift as a Doppler shift is again seen to be quite impossible.

## 2.10 The 2.7°K Cosmic Background Is Evidence For a Nonexpanding Universe

The fact that the 2.7°K cosmic background represents a reservoir of thermal energy at absolute rest throughout the universe is convincing evidence for absolute space and a uniform nonexpanding universe. This radiation can even be used as the absolute zero velocity rest frame from which the absolute velocity of the solar system can be measured (Conklin 1969; Henry 1971),

The origin of this 2.7°K background in a nonexpanding universe has been shown to be merely cosmologically red shifted starlight (Ward 1961; Troitsky 1996; Wesley 1996a). In particular, the fractional time rate of loss of radiant energy due to the cosmological red shift is

$$(dE/dt)/E = c(d\nu/ds)/\nu = H. \qquad (2.16)$$

Since the radiant energy density of the 2.7°K background is given by $aT^4$, where a is a universal constant, $a = 7.56 \times 10^{-15}$ erg/cm$^3$°K$^4$;



the time rate of loss of the radiant energy per unit volume due to the cosmological red shift is $aT^4H$. The rate that starlight energy is added to the universe per unit volume is nI, where n is the number density of galaxies equal to about $10^{-74}$ cm$^{-3}$ and I is the luminosity of a galaxy equal to about $3 \times 10^{44}$ erg/s. For a steady-state nonexpanding universe the two rates must be equal; thus,

$$nI = aT^4H. \qquad (2.17)$$

For a Hubble constant of 100 km/sMpsc the background temperature should then be

$$T = (nI/aH)^{1/4} = 3.4°K, \qquad (2.18)$$

which is in sufficient agreement with the observed value to indicate that the 2.7°K background is starlight attenuated by the cosmological red shift in a uniform steady-state nonexpanding universe.

This explanation of the origin of the 2.7°K background as cosmologically red shifted starlight also resolves Olbers' paradox. The flux of starlight at the Earth, that should otherwise be infinite in an infinite uniform nonexpanding universe, is attenuated by the cosmological red shift to give rise to the dark night sky at a temperature of 2.7°K. The night sky temperature was estimated from the starlight flux observed at the Earth by Regener (1931) as 3.2°K. This method is approximately equivalent to the direct measurement of the background radiation; because the starlight flux, dropping off exponentially with distance due to the cosmological red shift, is given primarily by the contributions of local stars.

Gamow (1956) claimed that the 2.7°K background is a remnant of a big bang cooled to 2.7°K by an adiabatic expansion of the universe. But this is quite impossible. Even if matter and radiation could escape from the huge gravitational field of such a super black hole (which would be impossible) and it were to explode into empty space, it could not yield an adiabatic expansion. As is well known from the explosions of novas, after a very short initial phase, there is a free nonadiabatic expansion of light and matter into empty space. Thus, the original character of a big bang would have been rapidly lost forever; and the origianl hot radiation would have long since disappeared into the empty Euclidean space beyond the finite nascent universe. At no time after the initial phase could the universe have

been dense enough to hold its hot background photons. The 2.7°K background would have long since disappeared from a finite transparent (as it is today) universe.

## 2.11 Rejuvenation of a Steady-State Eternal Universe

Probably the most important question that cosmology should try to answer is: How does a steady-state eternal nonexpanding universe escape the heat death implied by the second law of thermodynamics? Generally the question is ignored or answered superficially by postulating ad hoc mechanisms involving such things as "gravitons" (Edwards 1998; Jaakkola 1993; Kropotkin 1991), spontaneous creation of matter in empty space (Hoyle and Narliker 1974; MacMillan 1918), and ethers (Kipper 1974; Monti 1987; Nernst 1937).

In contrast, gravitational drag, that is observed in the laboratory (Pound and Rebka 1960) and is not ad hoc, provides a mechanism to rejuvenate a steady-state nonexpanding universe. Thermal energy of the lowest utility equal to the Carnot efficiency, such as the 2.7°K cosmic background and neutrino energy, is converted directly into gravitational potential energy of the highest unit utility. "Utility" is defined as the fraction of energy provided under given circumstances that can be converted to mechanical work, that can create the maximum thermodynamic order (Wesley 1991k, 1989b, 1974, 1996a). The increase in gravitational potential energy arises by virtue of a decrease in local mass density to produce a more uniform distribution of mass in the universe. The gravitational drag produces a *local* expansion of matter in the wake of photons.

An expanding universe does not demand any rejuvenation. The heat death is avoided by the waste high entropy thermal energy being radiated off into an ever increasing volume; so it can presumably enjoy an everlasting 2.7°K deep space temperature. Unfortunately, a worse fate lies in store for such an expanding universe with only a finite mass: It must eventually simply evaporate and disappear into a never ending infinite absolute Euclidean space.

In a steady-state universe the gravitational potential energy won from background radiation produced by a gravitational drag is lost in turn during mass condensation processes, such as produce stars.



The gravitational energy goes into heating the condensing matter. The condensation can only proceed by virtue of the matter losing some of its kinetic energy as thermal energy radiated off into deep space. The cooling permits the matter to become trapped in its own gravitational potential well. This condensation process represents an entropy reduction or thermodynamic ordering for the matter involved. The high entropy cold matter in interstellar space becomes low entropy hot matter in stars. This thermodynamic ordering process can only take place, and also satisfy the second law of thermodynamics, by virtue of entropy production. Excess high entropy must be created and radiated off into deep space as thermal energy.

After a condensation of matter has created high temperatures Wesley's (1996a, 1991l) law for ordering processes in nature is applicable, which states: *Statistical thermodynamic systems open to deep space with temperatures greater than 2.7°K proceed toward states of lower entropy or higher thermodynamic order.*

Thus the energy cycle is complete: from thermal background radiation, to gravitational potential energy, to stellar thermal energy, and back to the thermal background.

Since it does not seem that all of the condensing matter that gives rise to high temperature radiant energy is returned to deep space; it may be speculated that super massive bodies, that are admissible with Wesley (1968, 1988, 1991g) gravitation, might be semi-permanent sinks for matter. When two such super massive bodies collide or pass near each other, the tidal release of gravitational forces could again release matter to form galaxies that again generate more high temperature energy (Wesley 1969, 1991j).

## 2.12 Cosmic Scale Fluctuations Make a Universal Heat Death Impossible

The rejuvenation process described in the previous Section is not sufficient all by itself to explain how a steady-state universe avoids the heat death seemingly predicted by the second law of thermodynamics. If there were instantaneous equilibrium between the conversion of thermal photons to gravitational potential energy and the reverse process of gravitational potential energy creating thermal

photons directly, then clearly the second law would apply and the heat death would be inevitable. But the gravitational drag process is not directly reversible; so the second law of thermodynamics is not applicable; or it fails.

Statistical departures from equilibrium states that allow small local short time violations of the second law are well known as "fluctuations". Such fluctuations produce physical effects that would not be predicted from simply statistical long-time large sample averages. Thus, the second law is not always sufficient nor applicable. A rough order of magnitude estimate of the magnitude of such fluctuations may be obtained from the mean free path L for interacting molecules and the mean time $\tau$ between interactions, the "relaxation time". A large system taken over a long-time average will appear to be in thermodynamic equilibrium; and it will obey the second law of thermodynamics for this large scale viewpoint.

It can now be asked: What must be the size of a system and the time span necessary for the universe to appear to be in thermodynamic equilibrium and thus to obey the second law? And how big are the fluctuations in space and time where thermodynamic equilibrium does not exist and the second law is not applicable?

The only way a steady-state universe can establish an equilibrium state involves light (and to a lesser extent neutrinos) transferring energy and momentum over cosmic distances with the absolute velocity c. Thus, the mean free path for light (as well as for neutrinos), as given by the distance travelled L to lose half the energy due to the cosmological red shift, is

$$L = c\,\Delta E/EH = c/2H \simeq 5 \times 10^9 \text{ light years}, \qquad (2.19)$$

for H = 100 km/sMpsc. And the relaxation time is

$$\tau = L/c = 5 \times 10^9 \text{ years}. \qquad (2.20)$$

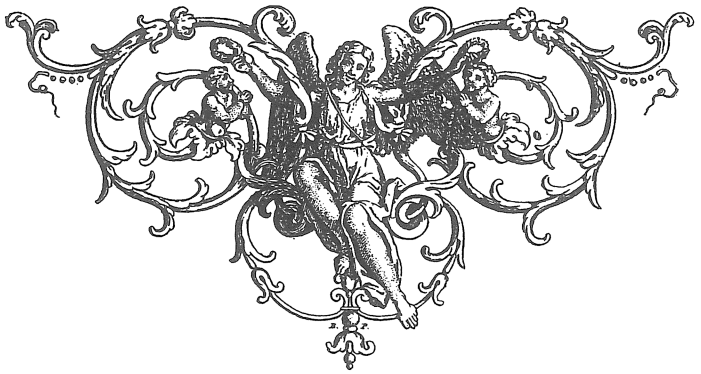
Clearly the gravitational drag process that rejuvenates the universe is not an equilibrium process that must obey the second law of thermodynamics.

The relaxation time for irreversible processes of $5 \times 10^9$ years is about the age of our Milky Way Galaxy. Thus, the nonequilibrium state of our local region out to $5 \times 10^9$ light years is apparently



a product of a local cosmic scale fluctuation. On a scale much greater than $5 \times 10^9$ light years over times much greater than $5 \times 10^9$ years the universe should appear uniform and in equilibrium. Thus, beyond $5 \times 10^9$ light years the universe should begin to appear uniform, as is observed. It would seem that a steady-state universe to be in equilibrium in-the-large would have to be essentially of infinite size.

A heat death for the entire universe is clearly impossible; as there will always be local fluctuations in space and time of the order of $5 \times 10^9$ light years and $5 \times 10^9$ years in which nonequilibrium processes can take place - especially thermodynamic ordering processes.



CHAPTER 3

# WESLEY GRAVITATION

Wesley (1991g, 1988, 1968) gravitation is a slight extrapolation from Newtonian gravitation in absolute space and time to include the additional *necessary* features: 1) a finite velocity of action equal to c, the velocity of light relative to absolute space, and 2) a mass equivalent of the gravitational field energy included as a portion of the source mass for the field.

## 3.1 The Differential Equation for the Gravitational Potential

Newton's universal law of gravitation for the force **F** on a mass m at **r** due to a mass m' at **r'**,

$$\mathbf{F} = - Gmm'\mathbf{R}/R \ , \tag{1.3}$$

where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$, is the same as Coulomb's law, $- Gmm'$ replacing $qq'$. It is, thus, postulated that gravitational theory may be derived from electrodynamics by changing the sign of the force from plus to minus. If only the two potentials, $\Phi$ and **A** are sufficient to characterize the electrodynamic field, then the analogous gravitational potentials may be defined as

$$\Phi = G \int d^3r' \rho'/R, \qquad \mathbf{A} = G \int d^3r' \mathbf{J}'/Rc \tag{3.2}$$

where $\rho'$ is the source mass density distribution, $\mathbf{J}'$ is the source mass current distribution, and c the velocity of light. Postulating a finite velocity of action c, as in electrodynamics, the potentials $\Phi$ and **A** in Eqs.(3.2) become retarded potentials that satisfy the differential equations

$$\nabla^2\Phi - \partial^2\Phi/\partial t^2c^2 = - 4\pi G\rho, \quad \nabla^2\mathbf{A} - \partial^2\mathbf{A}/\partial t^2c^2 = - 4\pi G\mathbf{J}/c, \tag{3.3}$$



for each cartesian component of **A**

The energy flux and density for longitudinal gravitational waves are given by multiplying the first of Eqs.(3.3) by $\partial\Phi/\partial t$ to obtain

$$\nabla\cdot\mathbf{S}_l + \partial E_l/\partial t = - \rho\partial\Phi/\partial t, \tag{3.4}$$

where

$$\mathbf{S}_l = \nabla\Phi(\partial\Phi/\partial t)/4\pi G,$$
$$E_l = - \left[(\nabla\Phi)^2 + (\partial\Phi/\partial tc)^2\right]/8\pi G. \tag{3.5}$$

The right side of Eq.(3.4) is the time rate that the mass density $\rho$ does work on the gravitational potential field $\Phi$.

Conserving mass, the mass current density **J** and the mass density $\rho$ are restricted by the equation of continuity,

$$\nabla\cdot\mathbf{J} + \partial\rho/\partial t = 0. \tag{3.6}$$

It may be shown that this condition (3.6) yields a condition on the potential fields, Eqs.(3.2) given by

$$\nabla\cdot\mathbf{A} + \partial\Phi/\partial tc = 0. \tag{3.7}$$

The energy flux and density for transverse gravitational waves may be obtained by taking the divergence of Eq.(3.7) and adding the result to the second of Eqs.(3.3) and using the identity

$$\nabla^2\mathbf{A} = \nabla(\nabla\cdot\mathbf{A}) - \nabla\times(\nabla\times\mathbf{A}), \tag{3.8}$$

to obtain

$$- \nabla\times(\nabla\times\mathbf{A}) - (\partial/\partial tc)(\nabla\Phi + \partial\mathbf{A}/\partial tc) = - 4\pi G\mathbf{J}/c. \tag{3.9}$$

Multiplying this result (3.9) by a vector **E**, defined by

$$\mathbf{E} = \nabla\Phi + \partial\mathbf{A}/\partial tc, \tag{3.10}$$

and using the identity $\mathbf{a}\cdot(\nabla\times\mathbf{b}) = - \nabla\cdot(\mathbf{a}\times\mathbf{b}) + \mathbf{b}\cdot(\nabla\times\mathbf{a})$ for any vector fields **a** and **b** yields

$$\nabla\cdot\mathbf{S}_t + \partial E_t/\partial t = - \mathbf{J}\cdot\mathbf{E}, \tag{3.11}$$

where

$$\mathbf{S}_t = c(\nabla\Phi + \partial\mathbf{A}/\partial tc)\times(\nabla\times\mathbf{A})/4\pi G,$$
$$E_t = - \left[(\nabla\Phi + \partial\mathbf{A}/\partial tc)^2 + (\nabla\times\mathbf{A})^2\right]/8\pi G. \tag{3.12}$$

The right side of Eq.(3.11) is the rate that the current **J** does work on the field **E**.

The energy to establish this transverse wave, Eqs.(3.3), and (3.12), is provided only by the work done by the current density J, given by $-\mathbf{J}\cdot\mathbf{E}$. But the mass density $\rho$ also does work on the field, as given by $-\rho\partial\Phi/\partial t$; so the net wave energy flux and density for a combined longitudinal and transverse wave subject to Eqs.(3.6) and (3.7) are

$$\mathbf{S}(\text{net}) = c\left[(\nabla\Phi + \partial\mathbf{A}/\partial tc) \times (\nabla \times \mathbf{A}) + \nabla\Phi(\partial\Phi/\partial tc)\right]/4\pi G,$$
$$E(\text{net}) = -\left[(\nabla\Phi + \partial\mathbf{A}/\partial tc)^2 + (\nabla\times\mathbf{A})^2 + (\nabla\Phi)^2 + (\partial\Phi/\partial tc)^2\right]/8\pi G. \quad (3.13)$$

The only case of interest here is the static case where $\mathbf{S}(\text{net}) = 0$ and

$$E(\text{net}) = -(\nabla\Phi)^2/4\pi G, \quad (3.14)$$

which is the case of a static field involving no gravity waves.

To satisfy mass energy equivalence a mass density $\rho^*$ may be associated with the gravitational field energy, Eq.(3.14); thus,

$$\rho^* = E/c^2 = -(\nabla\Phi)^2/4\pi c^2 G. \quad (3.15)$$

This mass density $\rho^*$ must itself form a portion of the source mass for the gravitational field; so the net source mass density is then

$$\rho(\text{matter}) + \rho^*(\text{field}). \quad (3.16)$$

The differential equation for the static field $\Phi$ for this source, Eq.(3.16), is given by the first of Eqs.(3.3) by replacing $\rho$ by $\rho + \rho^*$; thus, the desired differential equation becomes

$$\nabla^2\Phi = -4\pi G\rho + (\nabla\Phi)^2/c^2. \quad (3.17)$$

This result (3.17) may be seen to be simply Poisson's equation with the very small additional term $-(\nabla\Phi)^2/c^2$ on the right. This result (3.17), thus, constitutes a very small extrapolation from Newtonian gravitation to include a necessary finite velocity of action c and the source mass equivalent of the field energy.

## 3.2 The Search for Gravity Waves

The prediction of gravity waves, propagating with the velocity c with respect to absolute space, follows as a necessary elementary consequence of assuming a finite absolute velocity of action equal



to c, as indicated by Eqs.(3.3) through (3.13).

In contrast to electrodynamics, where charge current densities J, shielded from electrostatic effects, can give rise to observable transverse waves, transverse gravity waves, where the source mass must be multiplied by the small velocity factor v/c, would be far too weak to be observed. Only longitudinal gravity waves, the first of Eqs.(3.3), (3.4), and (3.5), where the force, varying as $\nabla\Phi$, is parallel to $S_1$, might be observable.

A rapidly revolving binary system of two massive stars might provide a source for gravity waves; since the $\Phi$ potential varies with time. An exploding star, or nova, remaining spherically symmetrical, could produce no variation in time in the far gravitational field. An exploding star or nova cannot yield gravity waves.

The coupling of a gravity wave to a static mass density $\rho$ in terms of the rate that energy is supplied is given by $\rho\partial\Phi/\partial t$, which can be expected to be very minute. No one has, as yet been able to detect gravity waves. Nature apparently does not provide any sufficiently energetic source of gravity waves near the Earth.

The early claim to having observed gravity waves by J. Weber (1969) was not justified (Wesley 1970, 1991m). (A paper written by the author in 1969, immediately after J. Weber published his claims, proved by 3 independent methods that J. Weber was observing thermal noise in his detectors and not gravity waves. The paper was promptly rejected for publication. As explained by the editor, he wished to spare J. Weber and his sponsors the *embarrassment*! It has been erroneously assumed that gravity waves would provide evidence for "general relativity". Because the impossiblity of J. Weber's claims was not published; countless man hours and millions of dollars have been subsequently wasted trying to detect gravity waves.) It is not clear what information would be gained even if gravity waves were to be detected. There seems to be little reason, therefore, to expend any large amount of money and effort trying to detect gravity waves.

## 3.3 The Wesley Gravitational $\Psi$ Potential

The differential Eq.(3.17) for the potential $\Phi$ can be linearized

by introducing a new potential function $\Psi$, the Wesley gravitational potential, defined by

$$\Psi = \exp(-\Phi/c^2) \qquad \text{or} \qquad \Phi = -\, c^2\, ln\, \Psi. \tag{3.18}$$

Substituting Eq.(3.18) into (3.17) yields

$$\nabla^2\Psi = \beta^2\Psi\ , \tag{3.19}$$

where $\beta^2 = 4\pi G\rho/c^2$ .

### 3.4 An Integral Equation for the $\Psi$ Potential

Considering the Green's function

$$\Lambda(r.\ r') = 1/|r - r'|, \tag{3.20}$$

that satisfies

$$\nabla^2\Lambda = -\,4\pi\delta(r - r'), \tag{3.21}$$

an integral equation can be derived that yields $\Psi = 1$ for $\rho = 0$ and $\Phi = 0$ by multiplying Eq.(3.19) by $\Lambda$ , and multiplying Eq.(3.21) by $(\Psi - 1)$, and subtracting to obtain

$$\nabla\cdot(\Lambda\nabla\Psi - \Psi\nabla\Lambda + \nabla\Lambda) = 4\pi\delta(r - r')(\Psi - 1) + \beta^2\Psi\Lambda\ . \tag{3.22}$$

Integrating over all space and using the divergence theorem, where $n\cdot(\Lambda\nabla\Psi - \Psi\nabla\Lambda + \nabla\Lambda) = 0$ on the sphere at infinity where n is a unit normal to the surface of the sphere at infinity, Eq.(3.22) yields the integral equation

$$\Psi = 1 - (G/c^2)\int d^3r'\,\rho(r')\,\Psi(r')/|r - r'|. \tag{3.23}$$

### 3.5 The First Order Approximate Solution

Since $(G/2c^2)$ is a small constant; taking the logarithm of Eq.(3.23) and noting the approximation $ln(1 - x) \simeq -x$ for x small, yields from Eq.(3.18)

$$\Phi \simeq G\int d^3r'\,\rho(r')\,\Psi(r')/|r - r'|. \tag{3.24}$$

### 3.6 Derivation of the Cosmological Constant

For the contribution to $\Phi$ due to the far masses in the universe, where the universe may be taken to have a uniform mean density $\rho_o$,



the appropriate expression for $\Psi$ is given by the asymptotic solution to Eq.(3.19) for $r \to \infty$, where

$$d^2\Psi/dr^2 \simeq \beta_o^2\Psi, \tag{3.25}$$

which has the solution that goes to zero for $r \to \infty$,

$$\Psi = \exp(-\beta_o r), \tag{3.26}$$

where the constant of integration has been chosen so that $\Psi = 1$ when $\beta_o = 0$, as it should.

Substituting Eq.(3.26) into Eq.(3.24) yields

$$\Phi = G\int d^3r'\,\rho(r')\exp(-\beta_o r)/|r - r'|. \tag{3.27}$$

This approximate result (3.27) is a slight extrapolation from Newtonian gravitation to include the cosmological constant $\beta_o$, where

$$\beta_o = \sqrt{4\pi G\rho_o/c^2}\ . \tag{3.28}$$

An arbitrary exponential cosmological constant is often introduced ad hoc in order to avoid mathematical divergence at infinity for $r \to \infty$. Sometimes this ad hoc constant is *postulated* to have certain physical properties. In contrast here the cosmological constant, Eq.(3.28), is derived as a necessary consequence of the fundamental theory itself. Its dependence upon the mean mass of the universe $\rho_o$ is a natural consequence of the theory.

If the mean mass density of the universe is assumed to be $\rho_o = 10^{-29}$ gm/cm$^3$, the cosmological constant, Eq.(3.28) has the very small value $\beta_o = 9.0 \times 10^{-29}$ cm$^{-1}$. The distance $r_o = 1/\beta_o$ for the field due to the distant masses in the universe to be reduced to 1/eth its original value is $r_o = 11 \times 10^9$ light years, or 11 milliard (11 billion in the US) light years - roughly the radius of the visible universe.

### 3.7 Resolution of Seeliger's Paradox

Seeliger (1909) pointed out that the gravitational attraction due to all bodies in a infinite universe of uniform mass density $\rho_o$ acting on a mass m would produce an infinite negative pressure on the body, if the force of attraction varies as the inverse square

of the distance. Thus, the force acting on the body at the origin due to the masses in the universe within the infinitesimal solid angle $d\Omega = \sin\theta\, d\theta\, d\phi$, as given by the inverse square law, is

$$dF/d\Omega = Gm\rho_o \int_0^\infty (r^2 dr)/r^2 \to +\infty. \tag{3.29}$$

With this infinite negative pressure the Earth should have exploded into empty space long ago.

Wesley gravitation yields a force of attraction falling off faster than the inverse square of the distance. In particular, for $\rho = \rho_o$ Eqs.(3.27) and (3.1) yield

$$dF/d\Omega = Gm\rho_o \int_0^\infty (r^2 dr) \exp(-\beta r)/r^2 = +Gm\rho_o/\beta, \tag{3.30}$$

which remains finite for an infinite uniform universe. For a universe where $\rho_o = 10^{-29}$ gm/cm$^3$ the force per unit solid angle per unit mass becomes

$$dF/d\Omega m = 10^{-8} \text{ dyne/gm steradian},$$

which constitutes a negligible negative pressure.

The Seeliger paradox arises from the fact that any effect varying as the inverse square of the distance from any point in a uniform infinite universe will yield an infinite effect. Thus, Olbers' paradox also yields an infinite light flux of starlight to the Earth from an infinite universe of uniformly distributed stars, if the intensity of light is assumed to fall off as the inverse square of the distance from a stellar source (Section 2.10).

Wesley gravitation, yielding the finite result (3.30), resolves Seeliger's paradox *automatically*.

## 3.8 The Gravitational Potential Due to an Infinite Universe of Uniform Mass Density

To compare Wesley gravitation with the Weber theory for gravitation (the following Chapter 4, Eq.(4.7)), it is of interest to calculate the potential $\Phi_o$ produced by an infinite uniform universe as prescribed by Eq.(3.27). Thus, at the origin $r = 0$ Eq.(3.27) yields

$$\Phi_o = 4\pi G\rho_o \int_0^\infty dr\, r \exp(-\beta_o r) = 4\pi G\rho_o/\beta_o^2 = c^2. \tag{3.31}$$



The Weber theory also gives $\Phi_o = c^2$, Eq.(4.40). Thus, the Wesley gravitational theory and the Weber theory applied to gravitation are in precise agreement with regard to the value of $\Phi_o$. This remarkable agreement tends to validate both theories.

## 3.9 The Total Mass in a Volume

The total mass $M'$ within a volume that reduces to the Newtonian theory for $\rho$ small and that includes the mass equivalence of the gravitational potential energy is given in terms of the Wesley potential $\Psi$, Eqs.(3.18), by

$$M' = \int_V d^3r' \rho \Psi, \tag{3.32}$$

where $\rho$ here is the material mass density. For $\rho$ small, $\Phi \simeq 0$, and $\Psi = 1$, Eq.(3.32) yields simply the material mass within the volume V. From Eq.(3.18) $\Psi$ to first order in $\Phi/c^2$ is given by

$$\Psi = \exp(-\Phi/c^2) \simeq 1 - \Phi/c^2. \tag{3.33}$$

To this approximation it is seen that the mass equivalent of the gravitational potential energy, $-\rho\Phi/c^2$, is thus added to the material mass density $\rho$ when computing $M'$ from Eq.(3.32).

It may be seen from Eqs.(3.18) and (3.19) that the definition (3.32) for $M'$ satisfies Gauss's law; namely,

$$M' = (c^2/4\pi G) \int_V d^3r' \nabla^2 \Psi = (c^2/4\pi G) \int_S da(\partial\Psi/\partial n), \tag{3.34}$$

where S is the surface enclosing the volume V and n is the outward unit vector normal to the surface.

## 3.10 The $\Psi$ Field of a Sphere of Uniform Material Mass Density

Solving Eq.(3.19) for the case where the material mass density $\rho$ is uniform within a sphere of radius R and is zero outside, subject to the boundary conditions that $\Psi$ and $\nabla\Psi$ are continuous across $r = R$, yields

$$\Psi = \begin{cases} \operatorname{sech}(\beta R) \sinh(\beta r)/\beta r, & \text{for } r \le R, \\ 1 - GM'/c^2 r, & \text{for } r \ge R, \end{cases} \tag{3.35}$$

where $\beta$ is defined by Eq.(3.19) and $M'$ is defined by

$$M' = (c^2R/G)\left[1 - \tanh(\beta R)/\beta R\right], \tag{3.36}$$

which satisfies Eq.(3.32).

For $\beta$ small Eq.(3.35) may be seen to reduce to $\Psi = 1 - \Phi/c^2$, where $\Phi$ is the usual Newtonian potential:

$$\Phi = \begin{cases} (GM_o/2R)(3 - r^2/R^2), & \text{for} \quad r \leq R, \\ GM_o/r, & \text{for} \quad r \geq R, \end{cases} \tag{3.37}$$

where $M_o = 4\pi\rho R^3/3$ is the material mass of the sphere.

## 3.11 The Limited Magnitude of the Wesley $\Psi$ Potential

A remarkable feature of the Wesley $\Psi$ potential is the fact that it can take on values only between zero and unity,

$$0 \leq \Psi \leq 1, \tag{3.38}$$

as may be seen from the definition, Eq.(3.18) for $0 \leq \Phi \leq \infty$. (This result (3.38) may be compared with the ludicrous *infinite* Schwarzschild singularity in empty space prescribed by "general relativity".)

Wesley gravitation predicts smaller effects than those predicted by Newtonian gravitation. This is made evident from the integral Eq.(3.23) by considering the following series solution: The zeroth approximation is $\Psi_o = 1$. Substituting this zeroth approximation under the integral sign in Eq.(3.23) yields a first approximation,

$$\Psi_1 = 1 - (G/c^2)\int d^3r'\,\rho/|r - r'|. \tag{3.39}$$

Substituting this first approximation under the integral sign yields a second approximation; etc. The series solution to Eq.(3.23) is then

$$\Psi = 1 - (G/c^2)\int d^3r'\,\rho/|r - r'| + (G/c^2)^2 \int d^3r'\,\rho/|r - r'| \int d^3r''\,\rho\,/|r' - r''| - \ldots \tag{3.40}$$

This is a series in powers of the small quantity $(G/c^2)$, which converges rapidly to some finite value. The second term on the right of Eq.(3.40) yields Newtonian gravitation. The third term on the right reduces the effect of the second term; so the exact solution yields gravitational effects slightly less than those of Newtonian gravitation. The Wesley $\Psi$ potential is thus well behaved.



## 3.12 The Energy Integral of the Motion for a Body in the Gravitational Field

Neomechanics (Section 1.10) specifies the rest-mass energy plus kinetic energy of a body of material mass m as

$$E_o = c^2 m\gamma = c^2 m/\sqrt{1 - v^2/c^2}. \tag{3.41}$$

The total effective mass M that can become coupled to the gravitational field is then

$$M = E_o/c^2 = m\gamma. \tag{3.42}$$

The force on a moving body in a gravitational field that agrees with the Newtonian gravitational limit for $v^2/c^2 = 0$ is from Eq. (3.18)

$$\mathbf{F} = d(m\gamma\mathbf{v})/dt = m\gamma\nabla\Phi = -c^2 m\gamma\nabla(ln\,\Psi). \tag{3.43}$$

Multiplying Eq.(3.43) by $\gamma\mathbf{v}$ and integrating yields the energy integral of the motion as

$$E = c^2 m\gamma\Psi, \tag{3.44}$$

where the constant of integration has been chosen to yield $E = c^2 m\gamma$ for empty space, where $\Psi = 1$.

This result (3.44) is seen to yield the Newtonian approximation for small velocities and a weak gravitational field; thus, using Eq.(3.18)

$$E \simeq c^2 m(1 + v^2/2c^2)\exp(-\Phi/c^2) \simeq c^2 m + mv^2/2 - m\Phi, \tag{3.45}$$

the rest-mass energy plus the kinetic energy plus the gravitational potential energy $U = -m\Phi$.

## 3.13 The Unexplained Portion of the Precession of the Perihelion of Mercury

The theoretical prediction of the precession of the perihelion of Mercury, using Newtonian gravitational theory and mechanics does not seem to quite agree with the observed value. Using

traditional approximate perturbation techniques and Newtonian theory for the effect of the other planets, the precession, according to Clemence (1947) and McVittie (1956), of the perihelion of Mercury should be 5557.2 ± 0.9" per century; whereas the observed value is 5599.7 ± 0.4" per century. An "unexplained" discrepancy of 43 ± 1" per century would appear to exist. This constitutes a small fractional discrepancy of only $8 \times 10^{-3}$. Since there is no proper accurate mathematical method for checking the accuracy of the traditional perturbation techniques, that ignore possible unusual effects, such as when, for example, the outer planets all happen to align themselves briefly with the Sun; the small fractional discrepancy may be simply due to a mathematical insufficiency. A modern computer program that takes into account the actual motion of the planets as a function of time could ascertain the actual accuracy of the traditional perturbation techniques.

In ignorance of the adequacy of the traditional perturbation techniques, the very small "unexplained" portion of the precession of the perihelion of Mercury cannot be used as a test for any gravitational theory beyond Newtonian gravitation. In addition there are physical aspects that are ignored in order to derive this questionable discrepancy. For example, the computations are for a Sun centered system instead of for the center of mass of the solar system. According to Nedved (1994), the discrepancy vanishes when the center of mass system is used. Clearly the orbit parameters of the planets must be first corrected for the permanent Bradley aberration due to the absolute velocity of the solar system (Section 1.8g), which may involve discrepancies of the fractional order of up to $v/c \simeq 10^{-3}$. According to Gerber (1898) the "unexplained" portion is due to the finite velocity of gravitational action or retarded time.

The "unexplained" portion of the precession of the perihelion of Mercury cannot be regarded as a serious empirical data point. It is not an *established* fact of nature. It cannot be legitimately used to test the validity of any gravitational theory beyond Newton. Despite the unacceptability of the evidence, authors, such as Schroedinger (1925) and Assis (1989), have proposed special ad hoc theories to explain only this presumed "unexplained" portion of



the precession of the perihelion of Mercury. (The *only empirical evidence* cited for "general relativity", not explained by Newtonian gravitation, is the seemingly fortuitous prediction of the numerical value of 43" per century for the presumed "unexplained" portion of the perihelion of Mercury. There is, thus, no acceptable empirical evidence for, nor theoretical justification for, "general relativity".)

Considering the great, but unjustified, interest in the "unexplained" portion of the precession of the perihelion of Mercury, it is of interest to see what Wesley gravitation predicts. For a body moving in a central force field a further integral, in addition to the energy integral, Eq.(3.44), is given by the angular momentum. Taking the vector product of r times Eq.(3.43) yields

$$\mathbf{r} \times d(m\gamma \mathbf{v})/dt = 0; \tag{3.46}$$

since the force F is in the direction of $-\mathbf{r}$. Integrating Eq.(3.46), yields the angular momentum as a constant of the motion,

$$\mathbf{L} = m\gamma \mathbf{r} \times \mathbf{v}. \tag{3.47}$$

In the plane of the motion perpendicular to L, where $v = r\dot{\xi}$,

$$m\gamma r^2 \dot{\xi} = L. \tag{3.48}$$

where $\dot{\xi}$ is the angular velocity. From Eqs.(3.46) and (3.44)

$$r^2 = (c^2 L/E)\Psi. \tag{3.49}$$

Solving Eq.(3.48) for $\dot{\xi}$ and letting $r = (dr/d\xi)\dot{\xi} = r'\dot{\xi}$ yields

$$(c^2 m^2 r^4/L^2 + r'^2 + r^2)\dot{\xi}^2 = c^2. \tag{3.50}$$

Substituting Eq.(3.50) into (3.49) then yields

$$r'^2 + r^2 = (E^2/c^2L^2)r^4/\Psi^2 - c^2 m^2 r^4/L^2. \tag{3.51}$$

The potential $\Psi^{-2}$ may be approximated using the solution given by the first of Eqs.(3.18) and the second of Eqs.(3.37) as

$$\Psi^{-2} = 1 + 2(GmM'/c^2)/r + 2(GmM'/c^2)^2/r^2,$$

where M' for the Sun may be taken as its observed mass. Making the substitution $r = 1/u$, Eqs.(3.51) and (3.52) yield

$$u'^2 + A^2(u - B)^2 - C^2 = 0, \tag{3.53}$$

where A, B, and C are constants that may be found from the equations

above. The solution to Eq.(3.53) is

$$u = B + (C/A)\cos(A\xi), \tag{3.54}$$

for $u = B$ when $A\xi = \pi/2$, and where

$$A^2 = 1 - 2(GM'E/c^3L)^2. \tag{3.55}$$

For the present approximation the total energy E for Mercury may be taken as simply the rest-mass energy of Mercury, $E = c^2m$.

The angular displacement $\Delta\xi$ necessary to return to the same value of u is

$$\Delta\xi = 2\pi/A. \tag{3.56}$$

The precession in one Mercury year is then

$$\delta\xi = 2\pi/A - 2\pi \simeq 2\pi(GM'E/c^3L)^2, \tag{3.57}$$

which equals 13.6" per century, which is 32% of the presumed "unexplained" portion of the precession of the perihelion of Mercury of 43" per century. No particular significance can be assigned to the Wesley gravitational result of 13.6" per century.

## 3.14 The Gravitational Red Shift

In a matter free region where $\Psi = 1$ a photon arises from the conversion of an equivalent amount of material mass m; thus,

$$E_o = h\nu_o = c^2 m\gamma. \tag{3.58}$$

In a gravitational field the material mass energy is given by Eq.(3.42); consequently in a gravitational field $\Psi$ the total energy of the photon is

$$E = h\nu\Psi, \tag{3.59}$$

where h is Planck's constant.

For a photon passing from the surface of a star, where from Eq.(3.18)

$$\Psi = \exp(-\Phi/c^2), \tag{3.60}$$

to the Earth's surface, where $\Psi$ is essentially unity, the frequency is red shifted in proportion to the loss in energy to pass out of the gravitational field of the star; thus,

$$-\Delta\nu/\nu = \Phi(\text{star})/c^2. \tag{3.61}$$



Taking the differential of Eq.(3.59), where E is constant and $\Delta E = 0$, the fractional change in the frequency of the photon for a fractional change in the $\Psi$ potential, using Eq.(3.18), is

$$\Delta\nu/\nu = -\Delta\Psi/\Psi \simeq \Delta\Phi/c^2. \tag{3.62}$$

For a spherically symmetric body, where the gravitational potential is

$$\Phi = GM/r, \tag{3.63}$$

the gravitational red shift then becomes

$$-\Delta\nu/\nu = (GM/c^2r^2)\Delta r. \tag{3.64}$$

This means that there is a violet shift when a photon passes from infinity into a gravitational field, $\Delta\nu/\nu = GM/c^2r$.

Since the potential energy is $U = -m\Phi$; the potential $\Phi$ on the Earth's surface at the height s is

$$\Phi = -gs \tag{3.65}$$

where g is the acceleration of gravity. There is thus a red shift for a photon when it increases its height; thus,

$$-\Delta\nu/\nu = g\Delta s. \tag{3.66}$$

By using the Mossbauer effect, Pound and Rebka (1960) were able to measure the red shift for photons proceeding upward in the Earth's gravitational field a distance $\Delta s$, thereby verifying Eq.(3.66).

This result (3.62), (3.64) and (3.66) involves only the mass equivalent of the photon energy in a Newtonian gravitational field. The gravitational red shift can thus only confirm Newtonian gravitation; and it cannot yield evidence in support of any theory beyond Newtonian gravitation.

Since the gravitational red shift has significance in cosmology (as discussed in Chapter 2); it is important to consider the consequences of the gravitational red shift. The frequency of the photon changes while in flight through a changing gravitational field; because the photon at the time of emission cannot know the value of the gravitational field where it will be absorbed, and this is true for every position along the photon's flight path. A photon can thus be coupled to a gravitational field. Photons

gravitationally coupled to the masses in the universe can explain the cosmological red shift as a gravitational red shift, where the photons also experience a red shift while in flight.

Since the photon loses energy continuously while in flight upward in the Earth's gravitational field; to conserve energy the energy lost must appear elsewhere. This lost energy can only be deposited as an increase in the gravitational potential energy of the Earth. In particular, conserving energy, Eq.(3.59) yields $E = h\nu\Psi \simeq h\nu - (h\nu/c^2)\Phi$, where $h\nu$ may be regarded as the kinetic energy and $-(h\nu/c^2)\Phi$ may be regarded as the potential energy of the photon of mass $(h\nu/c^2)$. A loss in kinetic energy must then be gained by the potential energy. A photon moving upward in the Earth's field from an initial height $s_1$ to a final height $s_2$, where $s_2 > s_1$, yields

$$-h(\nu_2 - \nu_1) = (h\nu_2/c^2)gs_2 - (h\nu_1/c^2)gs_1 > 0, \tag{3.67}$$

which is an increase in the potential energy. Since the photon does not exist before it is created nor after it is absorbed; this process means a mass $(h\nu_1/c^2)$ is lost to create the photon at height $s_1$ and a mass $(h\nu_2/c^2)$ materializes at the height $s_2$ upon the absorption of the photon. The Earth itself has gained potential energy equal to $-h\Delta\nu$.

Since this process is independent of the particular frequency $\nu$; it allows thermal photons of low utility in terms of statistical thermodynamic processes to be converted into gravitational potential energy with the greatest utility equal to unity. "Utility" is the fraction of the energy available that can be converted to useful work. On a cosmic scale this mechanism provides a means to rejuvenate the universe.

In order for this process to be effective photons passing through the universe must produce an increase in the gravitational potential energy of the universe. This can only be done by the photons decreasing the mass density for the same amount of material mass, which means that the photons must cause a dilation of local mass concentrations to yield a more uniform mass density for the universe. In particular, the gravitational potential self energy U



of a spherical mass distribution for a fixed mass M is given by

$$U = -\int_0^R d^3r'\rho\Phi = 8\pi^2 G\rho^2 \int_0^R dr\, r^2(R^2 - r^2/3) = -6GM^2/5R. \tag{3.68}$$

A dilation dR for a fixed amount of matter M then represents an increase in the gravitational energy; thus,

$$dU = (6GM^2/5R^2)dR > 0. \tag{3.69}$$

It should be noted that, for a system in thermal equilibrium, the gravitational red shift does not provide a means for converting worthless thermal energy (as low frequency photons) into gravitational potential energy of the greatest unit utility to, thus, permit a violation of the second law of thermodynamics. Since on the Earth, where thermodynamic equilibrium prevails, there are as many thermal photons proceeding downward as upward; the two processes are in statistical equilibrium. The gravitational red shift thus provides no possibility for any "rejuvenation" of the Earth's surface. However, on a cosmological scale, where the mean free path of a thermal photon is $5 \times 10^9$ light years, the gravitational red shift can produce a rejuvenation of the universe (See Section 2.11).

## 3.15 The Cosmological Red Shift

A photon originating in a sphere of arbritary radius R of uniform density $\rho$ moves outward a distance $\Delta r$ in a gravitational potential field given by the first of Eqs.(3.37). Conserving energy according to Eq.(3.59) then yields

$$\Delta E = h\Delta\nu\Psi + h\nu\Psi\Delta\Psi = 0, \tag{3.70}$$

which then gives the condition

$$\Delta\nu/\nu = -\Delta\, ln\,\Psi = \beta\Delta r(1/\beta r - \coth\beta r).$$

On the sphere at infinity $r \to \infty$; so $1/\beta r = 0$ and $\coth\beta r = 1$. Thus, the cosmological red shift becomes

$$\Delta\nu/\nu = -\beta\Delta r = -H\Delta r, \tag{3.71}$$

where H is Hubble's constant, variously estimated from observations to be between 50 and 100 km/sMpsec, or between 7 and $14 \times 10^{-29}$ $cm^{-1}$. The present theory for a universe with a density of $\rho = 10^{-29}$ $gm/cm^3$

yields

$$H = \beta = \sqrt{4\pi G\rho/c^2} = 71 \text{ km/sMpsec}, \qquad (3.72)$$

or $10 \times 10^{-29}$ cm$^{-1}$. Within the uncertainty in the observational values of H and within the uncertainty in the estimate of the density of the universe the present Wesley theory is confirmed.

It may be noted that the same solution to yield the gravitational red shift for a photon passing outward in the Earth's gravitational field, Eq.(3.37), has also been used here to explain the cosmological red shift. The difference is that the origin has been moved to a point at infinity. This means that the cosmological red shift is produced by photons passing outward from a gravitational potential well produced by the far masses in the universe. As will be shown in the next Chapter 4, the far masses in the universe produce nonvanishing effects. In particular, the far masses, in agreement with Mach's principle, produce a force on a body of mass m and acceleration a equal to $-ma\Phi_o/c^2$, where $\Phi_o = c^2$ is the local gravitational potential produced by the far masses in the universe, Eq.(3.31).

As discussed in the previous Section 3.14, the energy lost by the photons is deposited in the universe as increased gravitational potential energy involving the dilation of matter to produce a more uniform distribution of matter. Since the process converts thermal photons of low utility, being able to produce little useful work, to gravitational potential energy of unit utility, being able to be converted entirely into useful work; the cosmological red shift is evidence of a rejuvenating process for the universe. It is a process that appears to violate the second law of thermodynamics; but the process is not taking place in a closed system in thermodynamic equilibrium, so the second law is not applicable. As discussed in Section 2.12 the universe can never come into thermal equilibrium; so it can always be rejuvenated and will never experience a "heat death".

## 3.16 The Velocity of Light in a Gravitational Field

The number flux density of photons (or phonons) is proportional to the square of the frequency $\nu^2$. This weighting factor arises from the number of standing wave modes in a source (or in space) per unit frequency interval, as derived by Lord Rayleigh (1900, 1905). This weighting factor, proportional to $\nu^2$, also occurs as a factor in the Planck (1900, 1901) black body radiation formula. It is also necessary to give an empirical description of the propagation of seismic waves (Wesley 1963).



Since the number of photons is preserved as they move through a gravitational field, as discussed in Section 3.14 above; for a steady flow of photons the net rate of flow into a tube of flow must equal the net rate of flow out of the same tube, which yields the condition

$$\nu^2 c = \nu'^2 c'. \qquad (3.73)$$

From Eq.(3.59) the frequency $\nu'$ in a gravitational field $\Psi$ as compared with the frequency at infinity, where $\Psi = 1$, yields

$$\nu'^2 = \nu^2/\Psi^2 \qquad (3.74)$$

Substituting Eq.(3.74) into (3.73) then yields the velocity of light in a gravitational field as

$$c' = c\Psi^2 \simeq c(1 - 2\Phi/c^2). \qquad (3.75)$$

Since $\Psi$ is less than unity in a gravitational field; the velocity of light in a gravitational field is less than c.

Since the $\Psi$, appearing in Eq.(3.75), is defined by Newtonian gravitation; the slowing of the velocity of light in a gravitational field is explained by Newtonian gravitation, the conservation of energy of a photon in a gravitational field, Eq.(3.59), and the phenomenological requirement (3.73). No gravitational theory beyond Newton is thus needed.

## 3.17 Deflection of Starlight Passing Near the Sun

The speed of light in the gravitational field of the Sun from Eq.(3.75) is given by

$$c' = c(1 - 2GM/c^2 r), \qquad (3.76)$$

where M is the mass of the Sun. The fractional deflection of starlight in the direction x perpendicular to the light ray and measured from the center of the Sun is given from Eq.(3.76) by

$$d\delta = \left[(dc'/dx)/c'\right]dy = (2GMx/c^2r^2)dy, \qquad (3.77)$$

where y is taken along the direction of the light ray and $r^2 = x^2 + y^2$. The net deflection from $y = +\infty$ to $-\infty$ may be obtained by integration, where x may be approximated as a constant b equal to the projected lateral distance of the light ray from the center of the Sun, the "impact parameter"; thus the net deflection becomes

$$\delta = -4GM/c^2b, \qquad (3.78)$$

where the minus sign indicates a deflection toward the Sun. This result (3.78) is claimed to agree with the uncertain observations (McVittie 1960).

This result (3.78) depends solely upon the decrease in the velocity of light in the Sun's gravitational field. And the decrease in the velocity of light in a gravitational field depends only upon the conservation of energy for a photon moving in a gravitational field, as given by Eq.(3.59), and the necessary phenomenological condition (3.73). Thus, the deflection of starlight passing near the Sun cannot be used to justify any gravitational theory beyond Newtonian gravitation.

In addition, the very large experimental uncertainty in the observations together with possible systematic errors, such as a nonvanishing index of refraction for the residual gas envelope around the Sun, makes the observation of the deflection of starlight passing near the Sun entirely unsuitable as a test for any theory what-so-ever.

(As typical of many pseudoscientific theories that are based upon questionable effects, "general relativity" is empirically based upon the questionable "unexplained" portion of the precession of the perihelion of Mercury and upon the questionable deflection of starlight passing near the Sun. Although the latter effect probably does exist, as it follows from the elementary physics presented in this Section.)

## 3.18 Super Massive Bodies

It now seems to be clear that huge localized concentrations of mass-energy are needed to explain observations on a galactic



scale that involves: quasars, exploding galaxies, Seyfert galaxies, bridges between galaxies, high speed jets from galaxies, quasars associated with galaxies, clusters of galaxies, satellite galaxies, and the observations as reported in Arp's books (1987, 1998). Super massive bodies with masses of the order of the mass of a galaxy are needed to account for the origin of galaxies, as discussed in Section 3.19 below.

(It is important to note that "black holes" of "general relativity" are not super massive bodies! Being inside the Schwarzschild singularity, "black holes" cannot be observed outside the singularity; so they cannot even exist! Like "general relativity" itself, "black holes" are pure fantasy.)

Considering mass energy equivalence Newtonian gravitational theory does not permit the existence of super massive bodies of the mass of a galaxy. (The Chandrasekhar (1935) limit of "general relativity" of a few solar masses for the maximum mass of a gravitating body also precludes the existence of super massive bodies.) The net mass M of a body equals the material mass M' of the body plus the amss equivalent of the internal energy E of the body; thus,

$$M = M'(\text{material}) + E(\text{internal})/c^2\ , \qquad (3.79)$$

where for a solid body with no internal kinetic energy and uniform density $\rho$ the internal energy is the self gravitational potential energy. According to Newtonian theory this internal energy is given by Eq.(3.68). If this negative internal mass equivalent of the gravitational potential energy $U/c^2$, as given by Eq.(3.68), were to equal the material mass M', the net mass M would become zero; and the body would simply vanish. Thus, Eqs.(3.79) and (3.68) yield the condition for the greatest material mass that a body can have according to Newtonian theory; thus,

$$M' < (5c^3/12G)\sqrt{5/2\pi G\rho} \simeq 2 \times 10^{41}/\sqrt{\rho}\ \text{gm}. \qquad (3.80)$$

For a unit density, $\rho = 1\ \text{gm/cm}^3$, $M' < 10^8$ solar masses, which is too small for a super massive body that should have a material mass greater than the mass of a galaxy of about $10^{11}$ solar masses. For a sphere of nuclear matter with a uniform density of about

$10^{14}$ gm/cm$^3$ the maximum material mass of a body would be only about 10 solar masses.

Only Wesley gravitation predicts no limit to the mass of super massive bodies. For example, the net mass of a body of uniform density $\rho$ is given by Eq.(3.36). For a super massive body it may be assumed that $\beta R >> 1$, which means from Eq.(3.19) for $\beta$, that $R >> c/\sqrt{4\pi G\rho} \sim 10^{13}/\sqrt{\rho}$. For unit density the radius of a super massive body is thus assumed to be greater than 0.7 astronomical units, which seems reasonable. And for higher densities the radius could be even smaller and satsify the condition $\beta R >> i$. In terms of the mass of a super massive body this condition for $\rho = 1$ requires the mass be greater than about $10^6$ solar masses, which is also reasonable. For $\beta R >> 1$ Eq.(3.36) yields for a sphere of uniform density

$$M = c^2R/G, \tag{3.81}$$

which increases indefinitely with the radius R. Thus, Wesley gravitation prescribes no upper limit to the mass of super massive bodies.

It is of interest to see the relationship between the net mass M and the material mass M'. For a sphere of uniforma material mass density $R = (3M'/4\pi\rho)^{1/3}$; so Eq.(3.81) gives for a uniform density $\rho$ a net mass M varying as the 1/3rd power of the material mass M'; thus,

$$M = (c^2/G)(3M'/4\pi\rho)^{1/3}. \tag{3.82}$$

### 3.19 Origin of Quasars and Galaxies

When considering the origin of galaxies, it is necessary to explain why the typical spiral galaxy, that can be clearly seen, has only two arms. The simplest explanation occurred to me in 1956: A galaxy arises from the collision, or near collision, of two super massive bodies.

Each such super massive body should have a mass of the order of a galaxy in order to give rise to a galaxy. Such a large super massive body can be envisioned as a sphere of nuclear matter or a neutron sphere. All by itself such a super massive body should



be completely stable; since the huge gravitational field created at the surface of such a body would prohibit the escape of essentially all particles and light. The gravitational red shift for escaping photons should be essentially 100% or $\Delta\nu/\nu = 1$ or $z = \Delta\lambda/\lambda \to \infty$; no photons being able to escape to infinity with any significant amount of energy remaining. Such a super massive body would gravitationally attract and absorb all small bodies and radiation that come into its neighborhood. It would be a gigantic sink for mass and energy. It would appear to be a "black hole" (but not the "black hole" of "general relativity").

Such super massive bodies would seem to be ultimate sinks for all of the matter and energy in the universe; and the universe should finally vanish into super massive bodies. However, the mass–energy of super massive bodies can be returned to the universe when two such super massive bodies collide, or almost collide. When two such super massive bodies approach each other near enough the huge gravitational fields should create gigantic tidal bulges on the super massive bodies. Within these bulges the net gravitational field due to the gravitational forces acting in opposite directions should become drastically reduced. The nuclear matter or neutrons, being no longer compacted together by the huge gravitational pressures, could evolve electrons and ordinary matter with a tremendous release of energy (fission energy). Ordinary matter would then be jetted from the inner tidal bulges into the center between the two super massive bodies where the gravitational force vanishes. The outer tidal bulges should produce weaker jets of ordinary matter into outer space.

This scenario is reminiscent of Gamov's (1956) "big bang" as the origin of the universe from a sphere of neutrons. Obviously, Gamov's idea is not tenable as a neutron sphere with all of the mass of the whole universe would form a super massive body so stable that no matter nor energy could ever leave it; and it could, of course, not explode (See Chapter 2 for further discussion). The mechanism for the "explosion" of the more modest super massive bodies considered here as resulting from a collision, or near collision, between two such super massive bodies is physically

quite plausible.

The jets of ordinary matter directed toward the center field free region between the two super massive bodies would produce a recoil on the super massive bodies, causing them to be driven outward into empty space. Spiralling outward the two super massive bodies would continue to lose mass, which would leave trails of ordinary matter behind in which stars could condense out, giving rise to the shining two armed spiral pin-wheel of a galaxy. The frequently seen small irregular satellite galaxies at the ends of the arms of a regular spiral galaxy could be the final remnants of the two original super massive bodies, that have become too small and have exploded under the inner pressure of ordinary matter.

According to this scenario the spiral arms are moving outward, or are unwinding. The usual idea that galaxies are created from a condensation of intergalactic matter involves an inward motion of the arms that are winding up. This usual scenario for the formation of galaxies is similar to the scenarios for the origin of individual stars. This condensation idea has difficulty in explaining the peculiar two-armed spiral structure of galaxies. A condensation process should be spherically symmetrical.

In 1956, when I first entertained the above scenario for the origin of galaxies, I reasoned that in the early stages a prodigious amount of light should be emitted. And, since this light would be emitted when the two super massive bodies were still close together, the light escaping from the double massive body system would be drastically shifted toward the red. Moreover such a small two massive body system should show rapid variations in light intensity varying in order of months. I then reasoned that such a spectacular object could hardly go unnoticed; and, if it existed, it would have been observed long before. Consequently, I deposited my research in a back drawer. Even if I had submitted the theory for publication, it would not have been accepted.

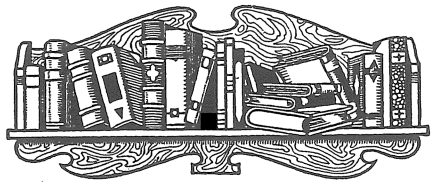
Much to my surprise, as well as the surprise of every-one-else, about 5 years later evidence started to accumulate that the objects that I predicted actually existed and became known as quasars. Much information has accumulated since the early 1960's concerning



quasars, that seem to confirm my (Wesley 1969) original conjecture that quasars are the early stage of the collision between two super massive bodies. Quasars are protogalaxies, objects that evolve into galaxies. A more detailed account of my theory of quasars can be found in my book *Advanced Fundamental Physics* (Wesley 1991j).

Once in 1967 at an American Physical Society Meeting I tried to interest Geoffrey Burbidge and Robert Dicke in my theory of the orgin of quasars and galaxies. I thought Burbidge would be particularly interested; because he believed that quasars were distributed like ordinary galaxies in the universe, and my theory yields this conclusion. It was generally assumed then, and is still generally assumed today, that the large red shift of the light from quasars is due to a cosmological red shift, that places quasars out at the edge of the visible universe. To my surprise both Burbidge and Dicke firmly rejected my theory as quite impossible; because super massive bodies could not exist. According to "general relativity" the largest possible mass that a body can have is given by the Chandrasekhar (1939) limit of only a few solar masses.

My gravitational theory, presented in this Chapter, was first conceived in 1952, but was only first publically presented in 1968 (Wesley 1968). I submitted a paper concerning my gravitational theory over five times to various physics journals over a period of two decades only to have it rejected each time; because it was not compatible with "general relativity", which is, of course, not a legitimate scientific theory. Finally I was able to get it published in 1988 (Wesley 1988, 1991g), 36 years after its first conception. The established journal system with its rigid censorship to eliminate new ideas and experimental results is a most serious obstacle to scientific progress.



CHAPTER 4

# ELECTRODYNAMICS

A single consistent valid electrodynamic theory that fits *all* experimental information is still unknown, despite more than 175 years of intensive research in the area. The material presented in this Chapter 4 is a more-or-less heterogeneous collection of topics, each with some merit, but each with perhaps some fault or some serious limitations.

There is no space here to review the long history and numerous theories that have been proposed. The original literature must be studied. The interesting two volume work by O'Rahilly (1936) presents many ideas from the past and present and provides many references; but no critical analysis is offered; and he champions the erroneous Ritz (1908) ballistic theory, involving action proceeding with the velocity c from a moving source charge.

The Maxwell (1891) electromagnetic theory, that is currently promulgated as an *orthodox religion*, that is supposed to give *all* the answers and that *all* physicists are supposed to *believe* without question, fails in numerous ways. It is not a valid fundamental theory; and it does not even provide reliable practical answers. Predictions of the Maxwell theory should be treated with suspicion; although some of its predictions may be correct. The insufficiency of the Maxwell theory is made clear by the examples discussed in the present Chapter 4.

The theory of electrostatics, based upon Coulomb's law for the force **F** on a charge q at r due to a charge q' at r', such that

$$\mathbf{F} = qq'\mathbf{R}/R^3, \tag{4.1}$$

where

$$\mathbf{R} = \mathbf{r} - \mathbf{r}', \tag{4.2}$$



is well developed mathematically and is sound empirically. All textbooks, including those presenting the Maxwell theory, present electrostatics without error. The field of electrostatics is accepted here as a well known empirically established theory that needs no further discussion in this book.

Magnetostatics is also largely well understood; although the magnetic behavior of materials is a highly involved and complicated subject all its own, that is not considered in this book.

Electrodynamics is the science involving the interactions between moving charges, as point charges or as continuous fluxes. It involves the fields generated by moving source charges and the action of these fields upon detector charges. It is an extremely difficult science with many problems remaining unresoved.

## 4.1 Relativity Versus Absolute Space?

Electrodynamics is faced with the unresolved problem of how to make a theory, that is valid only in absolute space, compatible with observations in an inertial frame (a nonaccelerating frame, a frame of reference moving with a constant uniform *absolute* velocity). In particular, local laboratory observations ordinarily do not involve the *absolute* velocity of the laboratory. Laboratory velocities, being measured with respect to the laboratory as stationary, are *relative* velocities. The physical laws ordinarily valid in the laboratory are, thus, *relativity* theories (The nonsensical "special relativity" is not a *relativity* theory. It is not considered here,). How can an *absolute-space* theory be converted to a *relativity* theory?

The universal absolute rest frame must have zero acceleration. The condition for absolute zero acceleration is readily determined in the closed laboratory. In a laboratory that is an inertial frame (i.e., a frame with an absolute zero acceleration) a body that is accelerated relative to the laboratory frame has precisely the same absolute acceleration. Thus, laboratory accelerations are in general also *absolute* accelerations. Since a body with mass m accelerated in the laboratory is acted on by a force **F**, according to Newton's second law; laboratory accelerations **a**, and thus *absolute*

accelerations, may be determined from $\mathbf{a} = \mathbf{F}/m$. Thus, absolute space, or the universal absolute rest frame, is a frame in which the laboratory acceleration is zero, as defined by Newton's second law.

Absolute space is defined by a nonaccelerating frame, or inertial frame, that has a zero *absolute* velocity. The absolute zero velocity frame may be determined in the laboratory as that frame in which the oneway velocity of energy propagation of light is isotropic and equal to c. In particular, if $c^*$ is the observed anisotropic oneway velocity of light, then the absolute velocity of the laboratory is given by $v = c^* - c$ (as discussed in Chapter 1).

It thus appears that the departure of relativity theory from absolute-space theory involves magnitudes of the absolute velocity v approaching the velocity of light, $v/c \lesssim 1$ (or $v^2/c^2 \lesssim 1$). (In principle, relative velocities can approach 2c.) The solar system with the Earth, moving through space with the absolute velocity of about 300 km/s, means that relativity theories, valid in the laboratory, will be valid as long as $v/c \lesssim 10^{-3}$ (or else $v^2/c^2 \lesssim 10^{-6}$. Or relativity theories can be regarded as valid as long as fractional errors of the order of $10^{-3}$ (or else $10^{-6}$) can be tolerated.

When particle velocities approach the velocity of light c, absolute space can play a role. For example, the gamma factor $\gamma = 1/\sqrt{1 - v^2/c^2}$, that occurs in neomechanics, where the mass increases with velocity as $m = m_o\gamma$, and the half life of moving radioactive particles is $\tau = \tau_o\gamma$, may be used to determine the absolute velocity of the laboratory (as actually done by Monstein and Wesley (1996) by measuring the anisotropy of the cosmic muon flux).

The limit velocity c may also play a role and be evident in Earth laboratories using relativity theory, if the velocity of the laboratory, where $v/c \approx 10^{-3}$, can be neglected (as was, for example, the case in Bertozzi's experiment measuring the mass increase with velocity, $m = m_o\gamma$, where he ignored the direction of his electron beam, the hour of the day, and the date. His fractional experimental



error for $v^2/c^2$ was much greater than $10^{-6}$.).

An absolute space theory can involve radiation, where light or *action* proceeds with the finite oneway *absolute* velocity c. A local relativity theory, that ignores absolute space, cannot involve radiation that propagates with respect to absolute space. Relativity theories include no finite velocity of action. Action-at-a-distance is, thus, assumed to be instantaneous. Coulomb's law and Newton's universal law of gravitation, involving only the *relative* distance R, Eq.(4.2), are *relativity* theories. They involve no finite velocity of action; the action is assumed to be instantaneous.

Since radiation does exist; and since it may be assumed that action can only proceed with a finite velocity less than or equal to c (see Chapter 1); relativity theories cannot be fundamentally correct. Yet action-at-a-distance theories form a practical legitimate basis for much empirical science, such as for celestial mechanics, and for Weber electrodynamics. It may be, thus, concluded that relativity theories can be valuable *approximations*. The degree of approximation may be readily ascertained: If the finite time for action to produce an effect is not involved, the time for action to proceed back and forth between two bodies must appear to be so short as to appear instantaneous. Thus, if L is the dimension, or size, of the system of interest, time intervals $\delta t$ of interest in relativity theories must be much greater than L/c; thus,

$$\delta t > L/c. \tag{4.3}$$

Relativity theories may also involve very rapid reciprocal action, such as the high frequencies involved in standing electrodynamic waves; as long as the net result, or net effect, is slowly varying, in agreemnet with Eq.(4.3).

Two conditions have, thus, been revealed for relativity theories to be valid approximations: 1) Particle velocities must be much less than c, $v/c \ll 1$; and 2) time intervals of interest $\delta t$ must be greater than the dimensions L of the system involved, $\delta t > L/c$. If these two conditions are violated, then corresponding unacceptably large implicit errors will be involved (which were

not involved in the Bertozzi experiment).

Unfortunately, the problem of primary interest is the reverse: How can an approximate relativity theory, that fits empirical facts, be converted into a valid absolute-space theory, that may not be directly subject to experiment? In particular, how can Weber's electrodynamics, that is a relativity theory and is empirically so extremely successful for small charge velocities and slowly varying effects, be generalized, or extended, to an absolute space theory valid for fast charges and radiation?

The conditions for radiation to actually occur are still not known. The Maxwell idea that any accelerating charge *must* radiate is clearly false; as the empirically tested Weber electrodynamics conserves energy in a closed system with accelerating charges and with no radiation.

Since a field theory is automatically an absolute-space theory, the fields being uniquely defined only in absolute space; rewriting the Weber theory in terms of fields should yield the desired absolute-space theory for electrodynamics (see Section 4.8 below),

## 4.2 Newton's Third Law

Newton's third law, where the force on one body must be accompanied by a force of equal magnitude oppositely directed acting on another body, has proved to be a major stumbling block for most proposed electrodynamic theories. For example, the Maxwell theory with the Lorentz force, which is based upon the Biot-Savart law, violates Newton's third law. As a consequence the Maxwell theory does not agree with a number of crucial experimental results (Wesley 1991n). Since Newton's third law must be satisfied in order to conserve energy; the failure to satisfy Newton's third law is a most serious matter.

Newton's third law is generally considered for a closed static system. By introducing the inertial force - ma as just another force on a body Newton's third law is preserved for dynamics as well as for statics. If radiation occurs, the inertial reaction of of the energy radiated with the absolute velocity c must also be included to satisfy Newton's third law. The inertial force due to



radiation is in general very minute; whereas, the usual violations of Newton's third law (as in the Maxwell theory) involve large forces; and in general concern situations where no radiation is involved. Static electrodynamic fields cannot themselves sustain any steady forces, that might be invoked in an attempt to satisfy Newton's third law.

Newton's third law is satisfied if 1) the law for the force between two bodies is antisymmetric to an interchange in the roles of the two bodies (Primes and unprimes interchanged changes the sign of the force.), and if 2) the force acts along the line joining the two bodies. It is a relatively simple matter to choose force laws that are properly antisymmetric (The Biot-Savart-Lorentz force of the Maxwell theory is *not* antisymmetric. The magnitude of the force predicted between current elements depends upon how the charges are labelled, which is taken as primed and which is taken as unprimed!)

The difficulty that remains unresolved is how to guarantee that a chosen force law between two moving charges acts along the line joining the two charges. If the antisymmetric force law does not act along the line joining the two bodies, a force couple exists that has no reaction torque; and the conservation of energy can be violated for rotational motion.

When the inertial force of reaction - ma is presented without specifying any further circumstances, it would appear that the direction of a can be any direction what-so-ever. This, however, is not true! The acceleration a can only be produced in the direction of the force necessary to produce the acceleration. In addition, the force is produced by an interaction with some other body of mass m'; and to conserve momentum this other body must also be accelerated in the opposite direction, such that

$$ma + m'a' = 0. \tag{4.4}$$

An acceleration a can, thus, not occur all by itself. Accelerations must always exist as an acceleration pair, a and a', that satisfy Eq.(4.4). All of the subsidiary conditions for a particular problem may not be explicitly stated. Usually the unstated implicit

subsidiary conditions automatically satisfy Newton's third law. For example, when the Biot-Savart law is used, it must be implicitly assumed that entire rigid closed current loop sources are involved; and, when such rigid closed current loop sources are involved, then Newton's third law is automatically satisfied. Maxwell theory, based on the Biot-Savart law, is thus also implicitly limited to macroscopic rigid closed current loop sources. It cannot provide the force between individual moving point charges; it is thus not a fundamental theory. Theories that are valid under special implicit circumstances have necessarily a limited range of applicability; and, in addition, there is always the danger that such theories will be applied to situations where they are not valid. The primary problem with the Maxwell theory is the unfortunate common belief, and claim, that it is *always correct* and *never fails*.

## 4.3 Weber Electrodynamics

The Weber (1841, 1848, 1893) theory is based upon the velocity potential, involving charge q at r and charge q' at r'; thus,

$$U_W = (qq'/R)\left[1 - (dR/dtc)^2/2\right], \tag{4.5}$$

where $R = |r - r'|$ and where

$$dR/dt = V\cdot R/R, \tag{4.6}$$

where $V = v - v'$ is the relative velocity. The first term on the right of Eq.(4.5) is the Coulomb potential energy, where

$$U_C = qq'/R; \tag{4.7}$$

so the Weber theory yields the empirically established electrostatics.

The time rate of decrease of the Weber potential energy $U_W$, Eq.(4.5), equals the rate that work is done on the charges q and q'; thus,

$$dU_W/dt = - v\cdot F - v'\cdot F' = - V\cdot F, \tag{4.8}$$

where Newton's thrid law has been used, $F' = - F$. Carrying out the time differentiation of Eq.(4.5), the force acting on the charge q



due to charge q' is given by

$$F_W = (qq'R/R^3)\left[1 + V^2/c^2 - 3(V\cdot R/cR)^2/2 + R\cdot dV/dtc^2\right]. \tag{4.9}$$

This Weber force is an action-at-a-distance theory that obeys Newton's third law. It is antisymmetric to an interchange of primes and unprimes, and it acts along the line joining the two charges, As discussed in Section 4.1 above, the Weber theory, Eqs.(4.5) and (4.6), can thus only be valid for slowly varying effects, as indicated by Eq.(4.3), and for charge velocities less than c, $v < c$ and $v' < c$. The outstanding virtue of the Weber theory is its ability to fit the empirical facts within its range of applicability.

It may be readily shown that the force between two wire elements carrying steady electron currents, taking into account all of the four forces between the moving negative electrons and the corresponding stationary positive lattice ions, yields the empirically correct original Ampere (1823, 1882) force formula

$$c^2d^2F_A = (II'R/R^3)\left[ - 2ds\cdot ds' + 3(R\cdot ds)(R\cdot ds')/R^2\right], \tag{4.10}$$

where qv has been replaced by the current element Ids, and q'v' by I'ds'.

The Weber theory also yields Faraday's law of electromagnetic induction for the electromotive force (emf) induced in an entire rigid closed current loop produced by a time changing current in another neighboring loop. From the fourth term on the right of Eq.(4.9), where q'dv'/dt is replaced by (dI'/dt)ds' gives

$$emf = \oint F_W\cdot ds/q = - (dI'/dtc^2)\oint\oint (ds\cdot R)(ds'\cdot R)/R^3. \tag{4.11}$$

Introducing the vector identity

$$(ds\ R)(ds'\cdot R)/R^3 = ds\cdot ds'/R - ds\cdot\nabla(ds'\ R/R), \tag{4.12}$$

the second term on the right, being a total differential, integrates to zero around the closed s loop; and Eq.(4.11) reduces to

$$emf = - (dI'/dtc^2)\oint ds\cdot\oint ds'/R. \tag{4.13}$$

Since (dI/dt)ds' may be written as $(\partial J/\partial t)da$ for a tube of flow of cross section da; and since the magnetic vector potential is defined by

$$A = \int J/cR; \tag{4.14}$$

Eq.(4.13) may be written as

$$emf = - \oint ds\cdot\partial A/\partial tc. \tag{4.15}$$

Using Stokes theorem, this result (4.15) yields

$$emf = - \int n\cdot(\nabla \times \partial A/\partial tc)da = - \int n\cdot(\partial B/\partial tc)da = - \partial \Phi / \partial tc, \tag{4.16}$$

where the definition $B = \nabla \times A$ has been introduced, where the integration is over the surface enclosing the closed loop, and where $\Phi$ is the magnetic B flux through the loop. This result (4.16) is Faraday's law of electromagnetic induction.

It is important to note that this result (4.16) does not mean that the emf is *caused* by the changing flux through the loop; since the use of Stokes theorem has not only obliterated the point charge q' to point charge q relationship by introducing a smeared out average around a closed loop, but it has also replaced the physically sound vector potential A by the physically questionable magnetic induction B.

## 4.4 The Biot-Savart Law

The Biot-Savart law for the force between current elements,

$$d^2F_B = II'ds \times (ds' \times R)/R , \tag{4.17}$$

does not obey Newton's third law. Interchaning primes and unprimes yields $d^2F'_B \neq - d^2F_B$; and the force does not act along the line joining the two current elements. Grassmann (1845) derived the Biot-Savart law from Ampere's law, Eq.(4.10) by simply neglecting the component of the Ampere force parallel to the current element. Grassmann argued erroneously that, since the longitudinal forces add up to zero around a closed mechanically rigid current loop, there is no way to distinguish between the Biot-Savart law and the Ampere law. And when integrated around an entire closed rigid current loop the Biot-Savart law satisfies Newton's third law for the loop as a unit. However, one is not limited to closed rigid current loop sources. The Ampere longitudinal force between colinear current elements cannot be neglected. Ampere himself was able to demonstrate empirically the existence of the longitudinal forces



in 1823 with his famous Ampere bridge experiment. (Further discussion and references to the original literature concerning the Weber theory and the failure of the Biot-Savart-Lorentz force law can be found in Wesley (1991n, 1992, 1996c).)

## 4.5 The Weber Potential from Inertial Mass Energy Equivalence

Since the inertial force - ma experienced by a body is opposite to its acceleration, taken as positive; it is possible to associate *inertial* mass with *negative* potential energy. In particular, an inertial mass M may be associated with the negative of the Coulomb energy given by Eq.(4.7); thus,

$$M = - U_C/c^2 = - qq'/c^2R. \tag{4.18}$$

The mass equivalent of the total internal energy of a closed system is associated with *plus* the internal potential energy of the system, which is contrary to Eq.(4.17) that is a function of the sign of the acceleration. The Bethe-Weizacker mass formula for the atomic masses of the elements has been derived using a mass equivalent associated with a (negative) Lennard-Jones nucleon-nucleon potential energy (Wesley and Green 1968).

Considering a positive charge q receding from a positive charge q', the rate that the Coulomb potential energy decreases equals the rate of gain of the kinetic energy. Using Eq.(4.18) then gives

$$dU_C/dt = - v\cdot d(M^*v)/dt = - v\cdot d\left[(m - U_C/c^2)v\right]/dt, \tag{4.19}$$

where M* is the total mass of of the charge q, its material mass m plus its Coulomb inertial mass $- U_C/c^2$.

$$M^* = m - U_C/c^2. \tag{4.20}$$

Integrating Eq.(4.19) yields the total energy E as

$$E = c^2m + (U_C - c^2m)\sqrt{1 - v^2/c^2}. \tag{4.21}$$

where the constant of integration has been chosen as $E - c^2m$. For v small compared with c, the case of interest here, Eq.(4.21) yields

$$E = U_C + (m - U_C/c^2)v^2/2. \tag{4.22}$$

The portion of the total energy given by

$$U = U_C(1 - v^2/2c^2) = (qq'/R)(1 - v^2/2c^2), \tag{4.23}$$

may be chosen as a velocity potential.

According to the derivation of Eqs.(4.21) and (4.23) the rate of decrease of the potential energy is *only* given by Eq.(4.19) if the velocity v is the direct rate of separation of the charge q from q'; as though only the two charges q and q' existed in an otherwise empty universe. Thus, the individual velocity v in Eqs. (4.19) through (4.23) should be replaced by the velocity of separation, given by

$$v \rightarrow (dR/dt)R/R = (R\cdot V)R/R\ , \tag{4.24}$$

where

$$V = v - v', \tag{4.25}$$

and where

$$v \rightarrow dR/dt = (R\cdot V)/R. \tag{4.26}$$

Here it is necessary to distinguish the "relative velocity" $V = v - v'$, which in general is not in the direction of R along the line joining the two charges, from the "velocity of separation" defined by Eq.(4.24). Thus, to be precisely correct and to satisfy Newton's third law the replacements (4.24) and (4.26) need to be made in Eq.(4.19) through (4.22). In particular, Eq.(4.24) then becomes the Weber velocity potential, as already given by Eq.(4.5).

## 4.6 Original Weber Theory for the Inertial Mass of an Accelerating Charge in a Uniform Electrostatic Potential Field

According to the original Weber theory the force on a charge q with an acceleration a (taken along the z axis) at the center of a hollow conducting sphere of radius b with a surface charge density $\sigma$ is given by the fourth term on the right in the brackets of Eq.(4.9). Making the replacement

$$q' \rightarrow \sigma b^2 d\phi\ d\theta \sin\theta\ , \tag{4.27}$$

the acceleration force on q is given by

$$F = (2\pi q \sigma b/c^2)\, a \int_0^{\pi} d\theta \sin\theta \cos^2\theta = (4\pi q \sigma b/3c^2)a = (q\Phi/3c^2)a. \tag{4.28}$$

The force specified by Eq.(4.28) is a force in the direction



of a on q due to its acceleration. It is implicitly assumed that there is another body or mechanism within the hollow sphere that causes the charge q to have the acceleration a. A static charge q alone placed inside a hollow charged conducting sphere experiences no force and will not accelerate. The inertial force experienced by a body is opposite to the direction of the acceleration; and it is, thus, opposite to the applied force in Newton's second law, that is necessary to overcome the force of inertia. This means that the force of inertia on a accelerating charge in a uniform electrostatic potential field is reduced by the force given by Eq.(4.28). This is equivalent to saying the accelerating charge in a uniform electrostatic potential field has an equivalent *negative* inertial mass $m = -|F|/|a|$.

According to Assis (1993) the result (4.28) means that the inertial mass of the charge in a uniform electrostatic potential field is

$$m(\text{Assis}) = -(q\Phi/3c^2) = -U/3c^2 \tag{4.29}$$

where $U = q\Phi$ is the potential energy of the charge q. But this result (4.28), involving $-U/3c^2$ instead of $-U/c^2$, violates mass energy equivalence, as specified by Eq.(4.18) (an equivalence that is needed to satisfy Mach's principle, as discussed in Section 4.8 below). Costa de Beauregard (1995) has also proposed the inertial mass equivalent equal to the negative of the potential energy, as given by Eq.(4.18).

## 4.7 A Proposed Modification of the Weber Acceleration Force

In order to satisfy mass energy equivalence for the inertial mass of an accelerating charge in a uniform electrostatic potential field (Section 4.6 above) the Weber relative acceleration needs to to be replaced by the acceleration a of charge q alone (or else by $-a'$ of q' alone); thus,

$$(R\cdot a)R/R \rightarrow a. \tag{4.30}$$

With this modification the acceleration force from Eq.(4.9) becomes

$$F = qq'a/c^2R\ . \tag{4.31}$$

Introducing the replacement (4.27) for q' and integrating over the charged conducting spherical shell of radius b then yields

$$\mathbf{F} = (4\pi q\sigma b/c^2)\mathbf{a} = (q\sigma/c^2)\mathbf{a}, \tag{4.32}$$

which satisfies inertial mass energy equivalence, $m = -q\Phi/c^2 = -U/c^2$, as given by Eq.(4.18).

In addition, it may be noted that the uniform electrostatic potential field produced by a uniformly charged sphere, that may be indefinitely large, has no preferred direction at the charge q. There is no way to define $\mathbf{R} = \mathbf{r} - \mathbf{r}'$, because there is no way to define $\mathbf{r}'$. The only direction that the charge can respond to is the direction of the acceleration a of the charge itself. Consequently, the replacement (4.30) is again seen to be justified.

The general empirical law valid for all induction phenomena is given by

$$\mathbf{F} = -q\mathrm{d}\mathbf{A}/\mathrm{d}tc, \tag{4.33}$$

for the force of induction F on the charge q, where the magnetic vector potential A, Eq.(4.14), is defined in terms of the source charge velocities (as discussed in Chapter 5). The time derivative of A then involves the acceleration of the source charges q' only (or the apparent acceleration experienced by a moving detector charge q). For induction the Weber relative acceleration must then be replaced by individual source charge acceleration; thus,

$$\left[\mathbf{R}\cdot(-\mathbf{a}')\right]\cdot\mathbf{R}/R \longrightarrow -\mathbf{a}'. \tag{4.34}$$

Induction phenomena again supports the replacement of the Weber relative acceleration by the individual charge accelerations, a or $-\mathbf{a}'$.

It may be noted that for the particular case of Faraday transformer induction in a rigid closed loop the Weber relative acceleration, the left side of Eq.(3.34), also yields the observed emf (as shown in Section 4.3 above).

A field theory, involving possible radiation, derived by extending the action-at-a-distance Weber theory, cannot involve the direct coupling between an accelerating source charge q' and an accelerating detector charge q, as given by the fourth term on the right side of Eq.(4.9). The accelerating source charge q' must give rise to a field, independent of the detector charge q. The field acts subsequently on the accelerating detector charge q, independent of the source charge q' at the moment of detection. Thus, the replacement of the Weber relative acceleration by the individual charge accelerations, a or $-\mathbf{a}'$, Eqs.(4.30) and (4.34), is fully justified.



When a source is decoupled from the detector through an intermediate field, the problem of how to satisfy Newton's third law and the conservation of energy arises. Field theories are, thus, subject to possible errors.

When associating an inertial mass with a particle in a uniform potential field, such as Eq.(4.18) for the Coulomb case, it is implicit that Newton's second law is satisfied in conjunction with still a *third* body, in addition to the particle itself and the body, or system, giving rise to the uniform potential field. It is implicitly assumed that an accelerating pair of bodies, as given by Eq.(4.4), is involved. It is clear that the problem of satisfying Newton's third law for three or more bodies can become complicated, when direct action at a distance is no longer available.

## 4.8 The Mikhailov Experiment for the Inertial Mass of an Accelerating Electron in a Uniform Electrostatic Potential Field

The Mikhailov (1999) experiment verifies directly the existence of an inertial mass equivalent of the potential energy of a charge, an electron, in a uniform electrostaic potential field, as given by Eq.(4.18), or $M = -qU/c^2$. An oscillating neon glow lamp was placed at the center of a hollow conducting sphere charged to the potential V to yield the desired uniform potential energy U = eV. The frequency of the light emitted by the glow lamp depends upon the net mass M*, Eq.(4.20). Varying the electrostatic potential V on the conducting sphere from - 3000 to + 3000 volts, he found a linear decrease in the ratio $(M^* - m_e)/m_e$, as expected from the theory. According to the theory this ratio should be for V = 3000 V

$$(M^* - m_e)/m_e = -U/c^2 m_e = -eV/c^2 m_e = 6 \times 10^{-3}. \tag{4.35}$$

He found the experimental value of $-(3.0 \pm 0.3) \times 10^{-3}$, which is about onehalf the theoretical value. Considering the large 10% fractional experimental error and the possibilities for systematic errors, the deviation from the theory is not great. The experiment certainly confirms the existence of an inertial mass associated with the potential energy of the electron accelerated in a uniform electrostatic potential field; even though the exact value of the coefficient may remain in question.

Costa de Beauregard (2000) has suggested that perhaps the 1/2 factor Mikhailov observes might be due to a sharing of the potential energy with the conducting hollow sphere.

An alternative independent method for measuring the inertial mass of an electron accelerating in a uniform electrostatic potential field should be undertaken, as a check on Mikhailov's reported results and to see if the inertial mass equivalent of the potential energy equals $-U/c^2$ (as it should in principle), $-U/3c^2$ (as chosen by Assis from Weber's original theory), or $-U/2c^2$ (as found in the laboratory by Mikhailov).

## 4.9 The Weber Theory Applied to Gravitation

The Weber potential, Eq.(4.5), and force, Eq.(4.9), can be converted to a gravitation theory by replacing $qq'$ by $-Gmm'$, as has been done, among others, by Tisserand (1872), Schroedinger (1925), Assis (1989), and Wesley (1991o). The Weber gravitation force $\mathbf{F}$ on a mass $m$ at $\mathbf{r}$ due to a stationary mass $m'$ at $\mathbf{r}'$ becomes

$$\mathbf{F} = -(Gmm'\mathbf{R}/R^3)\left[1 + v^2/c^2 - 3(\mathbf{R}\cdot\mathbf{v}/cR)^2/2 + \mathbf{R}\cdot\mathbf{a}/c^2\right] \tag{4.36}$$

For a continuous stationary source mass distribution $m'$ may be replaced by

$$m' \longrightarrow d^3r' \rho'(r'); \tag{4.37}$$

and Eq.(4.36) integrated over all space to yield

$$\mathbf{F}/m = (1 + v^2/2c^2)\,\nabla\Phi - \mathbf{v}(\mathbf{v}\cdot\nabla)\,\Phi/c^2 - \Phi\,\mathbf{a}/c^2 + (\mathbf{v}\cdot\nabla)^2\,\nabla\Lambda/2c^2 + (\mathbf{a}\cdot\nabla)\,\nabla\Lambda/c^2, \tag{4.38}$$

where the gravitational potentials $\Lambda$ and $\Phi$ are defined by

$$\Lambda = G\int d^3r' \rho' R \qquad \text{and} \qquad \Phi = \nabla^2\Lambda/2 = G\int d^3r' \rho'/R. \tag{4.39}$$



The correctness of the result (4.38) may be readily verified by substituting the definitions (4.39) into Eq.(4.38), performing the indicated operations, and finally replacing $\int d^3r' \rho'$ by $m'$ to recover Eq.(4.36).

Assuming the universe is infinite, uniform, and isotropic in the large, the cosmological principle, then the potentials $\Phi$ and $\Lambda$ produced by the far masses in the universe must be constant locally from point to point; so all of the terms involving differentiation with repect to $\nabla$ in Eq.(4.38) must vanish. Thus, the force produced by the far masses in the universe is given simply by $-m(\Phi_o/c^2)\mathbf{a}$, where $\Phi_o$ is the gravitational potential produced by the far masses.

In order to accelerate a body a local force must act against this force produced by the far masses; thus,

$$\mathbf{F}(\text{local}) = (m\Phi_o/c^2)\mathbf{a} = -(U/c^2)\mathbf{a} = m\mathbf{a}, \tag{4.40}$$

where $U = -m\Phi_o$ is the gravitational potential energy and $m$ is the inertial mass equivalent $m = -U/c^2$. This result (4.40) is seen to be Newton's second law; and Mach's principle is thereby verified; provided Weber's cosmological condition

$$\Phi_o = c^2, \tag{4.41}$$

is satisfied.

This result (4.40) also demonstrates the equivalence between inertial and gravitational mass, as implicitly assumed by Mach's principle.

The value for the gravitational potential due to the distant masses in the universe, given by Eq.(4.41), agrees with The same result derived from Wesley gravitation, Eq.(3.31), which is based upon entirely different principles. The agreement between Eqs. (4.41) and (3.31) tends to support both the Wesley and the Weber theories.

It may be noted that the inertial mass equivalent to the gravitational potential energy, $m = -U/c^2$, is *positive*; because $U$ is negative. The opposite is true for the electrostatic case: the mass equivalent to the electostatic potential energy, also given by $m = -U/c^2$, is *negative*; because the potential energy

is positive.

It is interesting to note, as pointed out by Costa de Beauregard (1999), that the result (4.41) follows directly from the postulation of an inertial mass equivalent equal to minus the potential energy of a body and Mach's principle, as indicated by Eq.(4.40); and no particular gravitational theory is needed.

This derivation of Mach's principle, Eq.(4.40), from Weber gravitation does not support Mach's idea of instantaneous action at a distance, where the distant stars are supposed to directly and instantaneously produce the inertial reaction - ma on a body. In agreement with the discussion in Chapters 1 and 2, the gravitational potential $\Phi_o$ due to the distant masses in the universe must exist physically locally in order to produce the instantaneous inertial effect observed upon the application of a force. It may be assumed that this local $\Phi_o$ field was established over eons of past time, that allowed for the action of distant stars to arrive to establish the local $\Phi_o$ field.

## 4.10 Wesley Electrodynamic Field Theory

The Wesley (1990a&b, 1991n, 1996c, 1997) field theory is an extension of Weber electrodynamics to fields. The interaction between a source charge q' and a detector charge q is established through an intermediary field, that is assumed itself to have physical reality, capable of transmitting action.

The fundamental physics of the Wesley field theory differs considerably from the Weber theory. The Wesley theory, involving fields defined with respect to absolute space, is an absolute space theory. It permits radiation propagated with respect to this absolute space. In contrast, the Weber theory is an action-at-a-distance theory, that implies instantaneous action and cannot involve radiation. The Weber theory can only be an approximation valid for slowly varying effects and small charge velocities, $v/c < 1$ (as explained in Section 4.1 above). The Wesley theory involves no such limitations. Rapidly varying effects and charge velocities approaching that of light are admissible.

The Wesley field theory, like the Weber theory, satisfies



Newton's third law. And, like the Weber theory, it thus conserves energy. (In contrast, the Maxwell-Lorentz theory, violating Newton's third law, except for macroscopic rigid closed current loop sources, does not in general conserve energy.) The Wesley field theory reproduces the empirical successes of the Weber theory for slowly varying effects, such as prescribed by Ampere's (1823) original law for the force between steady current elements.

The first step in the extension of the Weber theory to fields is to write the Weber force on a detector charge q at r with a velocity v and acceleration a due to a distribution of source charges, represented by a charge density $\rho'$, a current density $J'$, and a charge acceleration density $\partial J'/\partial t$ over all $r'$ space by making the replacements

$$q' \to \rho' d^3r', \qquad q'v' \to J' d^3r', \qquad q'a' \to (\partial J'/\partial t) d^3r', \tag{4.42}$$

in Eq.(4.9). Secondly the self velocity squared terms in Eq.(4.9),

$$v^2/c^2, \qquad v'^2/c^2, \qquad (v\cdot R/cR)^2, \qquad (v'\cdot R/cR)^2, \tag{4.43}$$

are neglected; because they have never been observed (e.g., Lemon et al 1992); and they would, in any case, be extremely minute, if they, in fact, exist. Moreover, it simplifies the mathematics to neglect these unproven forces.

Making the replacements (4.42) in Eq.(4.9), and neglecting the terms indicated by Eq.(4.43), the Weber force becomes

$$c^2 d^3F/d^3r'q = (R/R^3)\left[c^2\rho' - 2v\cdot J' + 3(v\cdot R)(J'\cdot R)/R^2 + (a\cdot R)\rho' - R\cdot\partial J'/\partial t\right]. \tag{4.44}$$

Integrating over all $r'$ space the force, Eq.(4.44), may be given in terms of the center of charge $\Lambda$ and the center of current N, where

$$\Lambda = \int d^3r'\,\rho' R, \qquad \text{and} \qquad N = \int d^3r'\, J'R/c. \tag{4.45}$$

It is convenient to also introduce the more familiar electrostatic scalar potential $\Phi$ and the magnetic vector potential A, defined by

$$\Phi = \nabla^2\Lambda/2 = \int d^3r'\,\rho'/R, \qquad A = \nabla^2 N/2 = \int d^3r'\, J'/cR, \tag{4.46}$$

where the $\nabla^2$ operator operates only on each cartesian component of N, and where, in general, for curvilinear coordinates

$$\nabla^2 N = -\nabla\times(\nabla\times N) + \nabla(\nabla\cdot N). \tag{4.47}$$

The force, Eq.(4.44), in terms of the potential fields, Eqs.(4.45) and (4.46), then becomes

$$\begin{aligned}\mathbf{F}/q = &-\nabla\Phi + \mathbf{v}\times(\nabla\times\mathbf{A})/c - \mathbf{v}(\nabla\cdot\mathbf{A})/c + (\mathbf{v}\cdot\nabla)\nabla(\nabla\cdot\mathbb{N})/c \\ &- \partial\mathbf{A}/\partial tc + \partial\left[\nabla(\nabla\cdot\mathbb{N})\right]/\partial tc + \mathbf{a}\Phi/c^2 - (\mathbf{a}\cdot\nabla)\nabla\Lambda/c^2,\end{aligned} \tag{4.48}$$

where only the two potentials $\Lambda$ and $\mathbb{N}$ are fundamental, the potentials $\Phi$ and $\mathbf{A}$ being functions of $\Lambda$ and $\mathbb{N}$, Eqs.(4.46). (This result (4.48) has been previously presented by Wesley (1990a&b, 1991n, 1996c, 1997) in terms of the potentials $\mathbf{G} = \nabla\Lambda = \int d^3r'\,\rho'\mathbb{R}/R$. and $\Gamma = \nabla\cdot\mathbb{N} = \int d^3r'\mathbf{J}'\cdot\mathbb{R}/R$. Four potentials were erroneously presented as being necessary; whereas, in fact, only the two potentials $\Lambda$ and $\mathbb{N}$ are necessary and are fundamental.)

The correctness of Eq.(4.48) may be readily verified by substituting the definitions Eqs.(4.45) and (4.46) into Eq.(4.48) and performing the indicated differentiations under the integral sign to recover Eq.(4.44).

Since the mathematical representation of fields involves a fixed point in $\mathbf{r}'$ space; the accelerating source charge, $q'\mathbf{a}'$, has been replaced by the partial time derivative, $\partial\mathbf{J}'/\partial t$ for a distribution of accelerating source charges, instead of the total time derivative, $d\mathbf{J}'/dt$, which would imply the rate of change in $\mathbf{J}'$ as seen by the moving detector charge q. In addition, the partial time derivative $\partial\mathbf{J}'/\partial t$ has been interpreted as yielding a partial time derivative of the potentials, the integral limits for the defining integrals being assumed to remain fixed in time. When it comes to motional induction (Chapter 5), where the point of view of the moving detector charge q must be considered, this procedure is apparently not entirely sufficient.

Besides reducing to the empirically correct results given by the Weber theory, the result (4.48) predicts the zero self torque on the Pappas-Vaughan (1990) Z-shaped antenna, where high frequencies are involved. The Maxwell theory, violating Newton's third law, predicts a large self torque on the antenna (Wesley 1991n).

## 4.11 Rigid Closed Current Loop Sources with No Free Charges



It is of some interest to inspect the Wesley field theory for the special case where the source current $\mathbf{J}'$ is in rigid closed current loops (which is the only admissible case for the Maxwell theory). In this case

$$\begin{aligned}\nabla\cdot\mathbb{N} &= \int \mathbf{J}'\cdot\mathbb{R}/c\mathbb{R} = (I/c)\oint(d/ds)\mathbb{R} = 0, \\ \nabla\cdot\mathbf{A} &= -\int \mathbf{J}'\cdot\mathbb{R}/c\mathbb{R}^3 = (I/c)\oint(d/ds)(1/\mathbb{R}) = 0,\end{aligned} \tag{4.49}$$

for each closed tube of flow with the current I. The force on charge q, as given by Eq.(4.48), then reduces to

$$\mathbf{F}/q = -\nabla\Phi + \mathbf{v}\times(\nabla\times\mathbf{A})/c - \partial\mathbf{A}/\partial tc - (\mathbf{a}\cdot\nabla)\nabla\Lambda/c^2 + \mathbf{a}\Phi/c^2. \tag{4.50}$$

If in addition there are no free source charges, so $\rho' = 0$, Eq. (4.50) becomes simply

$$\mathbf{F}/q = \mathbf{v}\times(\nabla\times\mathbf{A}) - \partial\mathbf{A}/\partial tc. \tag{4.51}$$

## 4.12 The Lorentz Force

For the special case of free unschielded static charges, as well as closed rigid current loop sources, that is detected by a charge q with a velocity $\mathbf{v}$ and zero acceleration $\mathbf{a} = 0$, the force given by Eq.(4.50) reduces to the Lorentz force

$$\mathbf{F}(\text{Lorentz}) = q\mathbf{E} + \mathbf{v}\times\mathbf{B}/c, \tag{4.52}$$

where the "electric field" $\mathbf{E}$ and the "magnetic field" $\mathbf{B}$ are defined by

$$\mathbf{E} = -\nabla\Phi - \partial\mathbf{A}/\partial tc, \qquad \mathbf{B} = \nabla\times\mathbf{A}. \tag{4.53}$$

The force term $q\mathbf{v}\times\mathbf{B} = q\mathbf{v}\times(\nabla\times\mathbf{A})$, when written in terms of current elements, is simply the Biot-Savart law, Eq.(4.17). Thus, the Lorentz force, like the Biot-Savart law, does not in general satisfy Newton's third law, nor the conservation of energy. The Lorentz-Biot-Savart law fails *immediately* if applied to the case of the force between two moving point charges. However, for the case of entire macroscopic closed mechanically rigid current loop sources the Lorentz force, Eq.(4.52), like the Biot-Savart law, satisfies Newton's third law (the special case for which Eq.(4.50) is valid).

With all of the necessary limitations involved, the Lorentz

force is only of limited value. It most certainly does not represent a fundamental force law. The magnetic **B** field, necessary for the Lorentz force, is limited to only *one* aspect of the vector potential **A** field, namely. the curl of **A**. The vector potential **A**, being defined directly in terms of the current sources, Eq.(4.46), is the fundamental physical field. The **A** field, being defined in terms of the sources, represents a *cause*. The **B** field, being defined by the force on a moving charge $q\mathbf{v}$, is a particular *effect*.

Since the Lorentz force is derived here under the assumption that the detector charge q is not accelerating; it cannot give the force on an accelerating charge. It cannot give the force on an accelerating charge produced by stationary charges, that causes the back emf (electromotive force) prescribed by the Lenz law.

The Lorentz force cannot yield the correct motion of an electron, or a charge with mass, when substituted into Newton's second law; because it requires from the outset that the charge should have no acceleration. In particular, the Lorentz force denies the existence of the electrostaitc inertial mass equivalent M, given by

$$M = - q\Phi/c \ , \tag{4.54}$$

from the last term on the right of Eq.(4.50) (as discussed in Sections 4.5 through 4.8 above).

In addition, the Lorentz force does not yield the empirically observed force producing motional induction (as discussed in Chapter 5).

## 4.13 Sources Involving Unshielded Charge Motion

The force on a moving charge q given by Eq.(4.48) has been derived under the assumption that the source charge density $\rho'$ may be chosen independent of the source current density $\mathbf{J}'$. This is in general possible; but, if the unshielded source charges are precisely the same charges that give rise to the source current, then the source charges are conserved such that the equation of continuity must be satisfied,

$$\nabla' \cdot \mathbf{J}' + \partial\rho'/\partial t \ = 0. \tag{4.55}$$



In this case the source charges, giving rise to the source current are not electrostatically shielded, as in the case of currents in metal wires. The present case is of particular interest for the electrodynamics of the charges in atoms and molecules.

Multiplying Eq.(4.55) by R and integrating over all space yields

$$\int (\nabla' \cdot \mathbf{J}')R = \int \nabla' \cdot (\mathbf{J}'R) + \int (\mathbf{J}' \cdot \mathbf{R})/R = - (\partial/\partial t) \int \rho' R. \tag{4.56}$$

Applying the divergence theorem,

$$\int \nabla' \cdot (\mathbf{J}'R) \ = \oint_S \mathbf{n} \cdot \mathbf{J}'R = 0; \tag{4.57}$$

since the source current $\mathbf{J}'$, being confined in a finite region, vanishes on the surface S at infinity. Introducing the potentials, Eqs.(4.45), Eqs.(4.56) and (4.57) then yield the condition

$$\nabla \cdot \mathbf{N} + \partial\Lambda/\partial tc = 0. \tag{4.58}$$

Similarly, multiplying Eq.(4.55) by 1/R, integrating over all space, and introducing the potentials from Eqs.(4.46), yields

$$\nabla \cdot \mathbf{A} + \partial\Phi/\partial tc = 0. \tag{4.59}$$

The force given by Eqs.(4.48), (4.45), and (4.46) is now restricted by the additional conditions (4.58) and (4.59) for the case of unshielded moving charges as the source.

## 4.14 The Differential Equations for the Potentials

The integral definitions (4.46) for the potentials, $\Phi$ and **A**, may be equivalently expressed as differential equations subject to appropriate boundary conditions. In particular, the scalar potential $\Phi$ satisfies the Poisson equation

$$\nabla^2\Phi = - 4\pi\rho, \tag{4.60}$$

where $\Phi$ and $\nabla\Phi$ are to be taken as continuous everywhere.

The fact that $\Phi$, defined by Eq.(4.46), is a solution to the Poisson Eq.(4.60) may be proved as follows: The Laplacian operator $\nabla^2$ operating on the integral expression for $\Phi$ yields zero for $\mathbf{r} \neq \mathbf{r}'$; thus,

$$\nabla^2\Phi = \int \rho' \nabla^2(1/R) = 0. \tag{4.61}$$

But for $\mathbf{r} = \mathbf{r}'$ and $R = 0$ the integral becomes singular, the integrand going to infinity. Integrating over the small spherical region, $\xi = |\mathbf{r} - \mathbf{r}'|$, where $\rho'$ is constant, yields from the divergence theorem

$$\rho' \int \nabla^2(1/\xi)d^3\xi = \rho' \int \mathbf{n}\cdot\nabla(1/\xi)d^3\xi = -\rho' \int d\Omega\, \xi^2/\xi^2 = -4\pi\rho'. \tag{4.62}$$

Combining Eqs.(4.61) and (4.62) then yields (4.60), as was to be proved.

It is convenient to summarize this analysis in terms of the delta function, where

$$\nabla^2(1/R) = -4\pi\delta(\mathbf{r} - \mathbf{r}'). \tag{4.63}$$

Similarly from the integral definition of the magnetic vector potential $\mathbf{A}$, Eq.(4.46), it may be shown that $\mathbf{A}$ satisfies the differential equation

$$\nabla^2\mathbf{A} = -4\pi\,\mathbf{J}/c, \tag{4.64}$$

where the Laplacian $\nabla^2$ operates on each cartesian component of $\mathbf{A}$. In general, for curvilinear coordinates

$$\nabla^2\mathbf{A} = \nabla(\nabla\cdot\mathbf{A}) - \nabla\times(\nabla\times\mathbf{A}), \tag{4.65}$$

where again $\mathbf{A}$ and its first derivatives are to be taken as continuous everywhere.

Substituting the expression for $\Phi$ in terms of $\Lambda$ from the first of Eq.(4.46) into Eq.(4.60) yields the desired differential equation for $\Lambda$; thus,

$$\nabla^4\Lambda = -8\pi\rho, \tag{4.66}$$

which is the inhomogeneous biharmonic equation, where again $\Lambda$ and its first derivatives are to be taken as continuous everywhere. Once a solution to this Eq.(4.66) has been found, the secondary scalar potential $\Phi$ can be found by differentiation, using the first of Eq.(4.46).

Substituting the expression for $\mathbf{A}$ in terms of $\mathbf{N}$ from the second of Eqs.(4.46) into Eq.(4.64) yields the desired differential equation for $\mathbf{N}$ as

$$\nabla^4\mathbf{N} = -8\pi\,\mathbf{J}/c, \tag{4.67}$$

which is again the inhomogeneous biharmoinc equation, where $\mathbf{N}$ and its first derivatives are taken as continuous everywhere. The biharmonic operator $\nabla^4$ operates only on the individual cartesian components of $\mathbf{N}$ in Eq.(4.67). In general, the vector identity (4.47) must be used twice for $\mathbf{N}$ expressed in curvilinear coordinates. Once a solution for $\mathbf{N}$ has been found from Eq.(4.67), then the secondary vector potential $\mathbf{A}$ may be obtained by differentiation, using the second of Eq.(4.46).



## 4.15 Extension of the Theory to Include a Finite Velocity of Action c

The field theory represented by the force on a charge q Eq.(4.48) moving in the potential field defined by Eqs.(4.45) and (4.46), that recovers the successes of the Weber theory for slowly varying effects and that satisfies Newton's third law, does not yield radiation. To extend the theory to include radiation a finite velocity of action c must be introduced by replacing the potentials, defined by Eqs.(4.45) and (4.56) by retarded potentials. The field at $\mathbf{r}$ is then given by the source at $\mathbf{r}'$ at an earlier, or retarded, time

$$t^* = t - R/c. \tag{4.68}$$

Only a proper field theory permits this extension, the field being able to transmit action with the finite velocity c. There is no way to introduce a finite velocity of action directly into an action-at-a-distance theory; because no physical mechanism is provided that can transmit the action at a finite velocity c.

The force on a moving charge q due to sources prescribed at an earlier time is given by replacing the potential fields, Eqs. (4.45) and (4.46), by retarded potentials defined by introducing the retarded time, Eq.(4.68), in the expressions for the sources, $\rho'$ and $\mathbf{J}'$; thus,

$$\begin{aligned} \Lambda_r &= \int d^3r'\,\rho'(\mathbf{r}', t-R/c)R, \qquad \mathbf{N}_r = \int d^3r'\mathbf{J}'(\mathbf{r}', t-R/c)R, \\ \Phi_r &= \int d^3r'\,\rho'(\mathbf{r}', t-R/c)/R, \qquad \mathbf{A}_r = \int d^3r'\mathbf{J}'(\mathbf{r}', t-R/c)/R. \end{aligned} \tag{4.69}$$

These retarded potentials, Eqs.(4.69), are solutions to differential equations where the Laplacian operator $\nabla^2$ is replaced

by the wave operator, or d'Alembertian; thus,

$$\nabla^2 \rightarrow \nabla^2 - \partial^2/\partial t^2 c^2 = \Box^2 \tag{4.70}$$

This replacement converts Laplace's equation to the wave equation, that the retarded potentials must satisfy. For example, the Laplacian operator $\nabla^2$ operating on the retarded potential $\Phi_r$ is obtained by first taking the gradient of the third of Eqs.(4.69); thus,

$$\nabla\Phi_r = -\int(\partial\rho'/\partial tc)\mathbb{R}/R^2 + \int\rho'\nabla(1/R). \tag{4.71}$$

The divergence of this result (4.71), including the singularity term, Eq.(4.62), then yields

$$\begin{aligned}\nabla^2\Phi_r &= \int(\partial^2\rho'/\partial t^2c^2)/R - \int(\partial\rho'/\partial tc)/R^2 \\ &\quad - \int(\partial\rho'/\partial tc)(\mathbb{R}/R)\cdot\nabla(1/R) + \int\rho'\nabla^2(1/R) \\ &= \partial^2\Phi_r/\partial t^2c^2 - 4\pi\rho.\end{aligned} \tag{4.72}$$

Subtracting $(\partial^2/\partial t^2 c^2)\Phi_r$ from Eq.(4.72) yields the desired wave equation

$$(\nabla^2 - \partial^2/\partial t^2c^2)\Phi_r = -4\pi\rho. \tag{4.73}$$

Introducing the wave operator, or d'Alembertian,

$$\Box^2 = \nabla^2 - \partial^2/\partial t^2c^2, \tag{4.74}$$

the retarded potentials, that take into account the finite velocity of action c, satisfy the following differential equations:

$$\begin{aligned}\Box^4\Lambda_r &= -8\pi\rho, & \Box^4 N_r &= -8\pi J/c, \\ \Box^2\Phi_r &= -4\pi\rho, & \Box^2 A_r &= -4\pi J/c.\end{aligned} \tag{4.75}$$

Only the $\Lambda_r$ and $N_r$ potentials are fundamental. The $\Phi_r$ and $A_r$ may be found in terms of $\Lambda_r$ and $N_r$ by differentiation by $\Box^2$.

The retarded potentials are to replace the nonretarded potentials in Eq.(4.48) for the generally valid force on a moving charge.

## 4.16 The Physics Implied by the Inhomogeneous Wave Equation

The inhomogeneous wave equation, (4.73) or Eqs.(4.75), specifies a wave velocity c that is constant in the r-space for $\nabla^2$. The



propagation properties are independent of the source functions $\rho'$ or $J'$. In particular, in regions where $\rho' = 0$ and $J' = 0$ in empty space an elementary plane wave solution to Eq.(4.73) is given by

$$\Phi = \sin[\omega(t - x/c)], \tag{4.76}$$

where $\omega = 2\pi f = 2\pi/T$ is the angular frequency, f the frequency, and T the period. The parameter $\omega$ is independent of c; it depends only upon the original source that generated the wave. The wavelength $\lambda$ may be defined as the distance the wave travels during a period, $\lambda = cT$; so the wavelength is a function of the wave velocity c.

Since the wave velocity c in Eqs.(4.75) in regions where the source is zero is fixed with respect to the r-space; it cannot be a function of the velocity of a source charge $v'$. The Ritz (1908) ballistic theory for light (as an electrodynamic wave), where the wave velocity is postulated to be $c + v'$, cannot therefore be represented by the inhomogeneous wave equation, Eqs.(4.75). (The Ritz theory is wrong in any case (Wesley 1991p).)

Since the wave velocity c is constant in the r-space; it cannot be a function of the velocity of a moving observer. In the observer's frame of reference taken to be at rest the observer sees a oneway velocity $c^*$, given by

$$c^* = c - v, \tag{4.77}$$

where the observer is taken to be receding from the source. (A theory involving a velocity of light, or action, that depends upon the velocity of the observer v, such as "special relativity", violates *causality*; as the light would have to *know* the observer's velocity at the prior time of emission.)

It may be concluded that the inhomogeneous wave equation (4.73) can only represent a physical wave in a preferred frame of reference, the r-frame, in which the wave velocity c is a constant. The inhomogeous wave equation can represent a sound wave in the reference frame of a stationary gas, liquid, or elastic solid. It can represent a light wave in a fixed luminiferous ether, or in absolute space.

All of the experimental and observational evidence (reviewed in Chapter 1) reveals the velocity of light c, and thus action, is defined with respect to the physical absolute rest frame. Thus, the r-space for the inhomogeneous wave equation represents physical reality, if the r-space is taken to be isomorphic with the unique physical absolute rest frame. The observer velocity v in Eq.(4.77) must, thus, be chosen as the observer's *absolute* velocity.

## 4.17 The Retarded Distance

A signal proceeding from a source with the velocity of action c, independent of the source velocity, requires a time $\Delta t$ to reach the observer at the position r(t), where

$$\Delta t = |\mathbf{r}(t) - \mathbf{r}'(t - \Delta t)|/c = R_r/c, \tag{4.79}$$

where $R_r$ is the retarded distance.

If $\mathbf{R} = \mathbf{r}(t - \Delta t) - \mathbf{r}'(t - \Delta t)$ is the initial instantaneous separation distance between source and observer, and if the observer moves with the constant velocity v, then at the time t the retarded distance $R_r$ is

$$R_r = R + v\,\Delta t = R + vR_r/c. \tag{4.80}$$

During the time $\Delta t$ after the action, or signal, has left the source and before it has arrived at the observer the action itself is independent of both source and the observer; as may be envisioned by a flight of photons moving with the velocity c relative to absolute space.

Solving Eq.(4.80) for $R_r$ for the present case of an observer moving with the constant velocity v yields

$$R_r = \left[(v\cdot R/c) + \sqrt{(v\cdot R/c)^2 + (1 - v^2/c^2)R^2}\right]\Big/(1 - v^2/c^2). \tag{4.81}$$

For the case of an observer moving directly away from the source with the velocity $v < c$, Eq.(4.81) reduces to

$$R_r = R/(1 - v/c). \tag{4.82}$$

And the retarded time interval then becomes

$$\Delta t = R/(c - v). \tag{4.83}$$

These results (4.81) through (4.83), involving a constant observer velocity only, may be regarded as a first order approximation for general observer motion.



The retarded Coulomb potential for a point charge is given by the apparent distance to the charge as seen by the moving observer; thus,

$$\Phi_r = q'/R_r \tag{4.84}$$

For the case of an observer moving with the constant velocity v directly away from the charge the retarded potential becomes

$$\Phi_r = q'(1 - v/c)/R. \tag{4.85}$$

## 4.18 The Green's Function for the Wave Equation

It has been shown in Section 4.15 above that introducing retarded time into the integral definitions of the potentials yields retarded potentials, Eq.(4.69), that are solutions to the inhomogeneous wave equations (4.75), as proven by the direct differentiation of the retarded potentials. It is of interest for some applications to consider the reverse analysis, the derivation of the integral expressions from the inhomogeneous wave equations. In particular, for the scalar case, the Green's function (e.g., Jackson 1965) that satisfies

$$(\nabla^2 - \partial^2/\partial t^2 c^2)G(\mathbf{r},t;\mathbf{r}',t') = -4\pi\,\delta(\mathbf{r} - \mathbf{r}')\,\delta(t - t'), \tag{4.86}$$

where $\mathbf{r}'$, $t'$ are independent variables for any arbitrary space-time position r, t. Solving Eq.(4.86) for G vanishing at $\mathbf{r}'$, $t'$ at infinity yields

$$G(\mathbf{r},t;\mathbf{r}',t') = \delta(t - t' - |\mathbf{r} - \mathbf{r}'|)/|\mathbf{r} - \mathbf{r}'|. \tag{4.87}$$

Multiplying Eq.(4.86) by $\Phi$ and Eq.(4.73) by G and subtracting and integrating the result over all $\mathbf{r}'$, $t'$ space and time, using the divergence theorem, where $\Phi$ and G vanish on the sphere at infinity, yields

$$\Phi(\mathbf{r}.t) = \int d^3\mathbf{r}' \int dt'\, \rho'(\mathbf{r}',t')\,\delta(t - t' + |\mathbf{r} - \mathbf{r}'|/c)\Big/|\mathbf{r} - \mathbf{r}'|, \tag{4.88}$$

where the integration is taken over all $\mathbf{r}'$, $t'$ space and time, where $\mathbf{r}'$ is *independent* of $t'$. Performing the time integration then yields

$$\Phi_r(\mathbf{r},t) = \int d\,\mathbf{r}'\,\rho'(\mathbf{r}',\,t_r)/|\mathbf{r}-\mathbf{r}'|, \tag{4.89}$$

where $t_r$ is the retarded time defined by Eq.(4.68), or

$$t_r = t - |\mathbf{r}-\mathbf{r}'|/c. \tag{4.90}$$

The space integration in Eq.(4.89) is to be carried out regarding $t_r$ as a constant; because $\mathbf{r}'$, being independent of $t'$, must also be taken as independent of $t_r$.

The retarded Coulomb potential for a point charge is obtained by substituting

$$\rho'(\mathbf{r}',t_r) = q'\delta\left[\mathbf{r}' - \mathbf{r}(t_r)\right], \tag{4.91}$$

in Eq.(4.89) and performing the integration, regarding $t_r$ as constant, which then yields the correct directly derived result (4.84). For an observer moving with the constant velocity $\mathbf{v}$ the retarded distance $R_r$ is given by Eq.(4.81), and, when receding directly from $q'$, by Eq.(4.82).

## 4.19 The Lienard-Wiechert Retarded Potentials Are Wrong

Because all textbooks (e.g., Jackson 1965b), presenting Maxwell electromagnetic theory, present the Lienard-Wiechert retarded potentials; it is important to note that they are not correct. The idea of retarded time and retarded potentials is *physically* correct; but the Lienard-Wiechert expressions for the retarded potentials are *mathematically* incorrect (Wesley 2001).

Despite the clear mathematical requirement that $\mathbf{r}'$ and $t'$ be independent variables, independent of each other, in the integral representation of the retarded potential, the third of Eqs.(4.69), or (4.89) and (4.90); Lienard and Wiechert argue incorrectly that the *independent* space variable $\mathbf{r}'$ is a *dependent* function of the time variable $t'$. Thus, for example, in Eq.(4.88) the delta function is incorrectly interpreted to mean

$$\delta(t-t'+|\mathbf{r}-\mathbf{r}'|/c) = \delta(t-t'+|\mathbf{r}-\mathbf{r}'(t')|/c) = \delta(t-t'(R)); \tag{4.92}$$

as though $\mathbf{r}'$ represented the *dependent* position of a source charge at $\mathbf{r}'$ at the instant $t'$, instead of being merely any *independent* position $\mathbf{r}'$ anywhere at all in space - a dummy variable of integration. Moreover, this incorrect assumption that $\mathbf{r}'$ is a *dependent* functions of $t'$ implicitly assumes that the action proceeds with the velocity $c$ with respect to a moving point source charge with the net velocity $\mathbf{c} + \mathbf{v}'$, which is the empirically incorrect Ritz ballistic theory. The falsely interpreted delta function in Eq. (4.92) may be written as

$$\begin{aligned}\delta(t'-t-|\mathbf{r}-\mathbf{r}'(t')|/c) &= \delta(t-t')/d(t'-t-|\mathbf{r}-\mathbf{r}'(t')|/c)/dt' \\ &= \delta(t-t')/(1 - \mathbf{R}_r\cdot\mathbf{v}_r'/cR_r),\end{aligned} \tag{4.93}$$

where $\mathbf{R}_r = \mathbf{r} - \mathbf{r}'(t')$ and $\mathbf{v}_r = d\mathbf{r}'/dt'$. But since $\mathbf{r}'$ must be independent of $t'$; no $\mathbf{v}_r' = d\mathbf{r}'/dt'$ can be logically defined! Substituting the unjustified expression (4.93) into Eq.(4.88) and performing the integration over $t'$ yields the incorrect Lienard-Wiechert retarded potential as

$$\Phi_r(\text{Lienard-Wiechert}) = \int d^3r'\,\rho'(\mathbf{r}',\,t_r)/(R_r - \mathbf{R}_r\cdot\mathbf{v}_r'/c). \tag{4.94}$$

For a moving point charge the incorrect Lienard-Wiechert retarded potential is given by substituting the source function (4.91) into (4.94) to yield

$$\Phi_r(\text{Lienard-Wiechert}) = q'/(R_r - \mathbf{R}_r\cdot\mathbf{v}_r'/c). \tag{4.95}$$

For the case where an observer moves with the constant velocity $v$ directly away from the source charge $q'$, moving colinearly with the velocity $v'$, Eq.(4.95) and (4.82) yield

$$\Phi_r(\text{Lienard-Wiechert}) = q'(1 - v/c)/R(1 - v'/c). \tag{4.96}$$

These results (4.95) and (4.96) do not agree with the correct results derived directly, as given by Eqs.(4.84) and (4.85), which satisfy the inhomogeneous wave equation (4.73), as well as being deriveable from the integral representation (4.89).

The Lienard-Wiechert retarded potentials, Eq.(4.94) through (4.96) do not satisfy the inhomogeneous wave equation (4.73), as they should to be correct.

(The Lienard-Weichert retarded potentials are also not prescribed by the Maxwell theory, where they are also wrong.)

## 4.20 The Radiation Field

The differential equations (4.75) for the potentials $\Lambda$, $\mathbf{N}$,

$\Phi$, and $\mathbf{A}$ (dropping the subscript r) are all wave equations. They all prescribe a wave velocity c in the r-space, that can only be the physical absolute rest frame. Only the potentials $\Lambda$ and $\mathbf{N}$ are fundamental; because the traditional $\Phi$ and $\mathbf{A}$ potentials are defined in terms of $\Lambda$ and $\mathbf{N}$ by

$$\Phi = \Box^2\Lambda/2 \qquad \text{and} \qquad \mathbf{A} = \Box^2\mathbf{N}/2\,, \tag{4.97}$$

where $\Box^2 = \nabla^2 - \partial^2/\partial t^2c^2$ is the d'Alembertian operator, and where only cartesian components of $\mathbf{N}$ are to be used, otherwise the vector identity (4.47) is to be used.

The radiation field becomes decoupled from the original source; since it proceeds with the absolute velocity c from the source, and no action is assumed to be able to propagate with an absolute velocity greater than c. Thus, the nature of the radiation field can be investigated by assuming the simplest possible original sources that give rise to the radiation field. Since the source for the propagating $\Phi$ field is $\rho$ and for the propagating $\Lambda$ field is $\rho/2$; and since the $\Phi$ field can be defined in terms of the $\Lambda$ field, the first of Eqs.(4.97); it is postulated that only the mathematically simpler $\Phi$ field is necessary to prescribe the radiation field. Similarly, since the source of the $\mathbf{A}$ field is $\mathbf{J}$ and the source of the $\mathbf{N}$ field is $\mathbf{J}/2$; and since the $\mathbf{A}$ field can be defined in terms of the $\mathbf{N}$ field, the second of Eqs.(4.97); it is postulated that only the mathematically simpler $\mathbf{A}$ field is necessary to prescribe the radiation field.

For charges that must act both as sources of fields and as detectors of fields simultaneously, the mathematically more complex $\Lambda$ and $\mathbf{N}$ fields are necessary to satisfy Newton's third law. For charges that act as sources only, it is postulated that the mathematically simpler $\Phi$ and $\mathbf{A}$ fields only are sufficient. Thus, the far fields can be prescribed by $\Phi$ and $\mathbf{A}$ alone; whereas the near fields must involve $\Lambda$ and $\mathbf{N}$ in general.

## 4.21 The Transverse Magnetic Wave

The simplest electrodynamic wave involves only the vector potential $\mathbf{A}$. This wave may be produced by an oscillating current



in a circular loop antenna. For a small loop this may be regarded as an oscillating magnetic dipole source. The $\mathbf{A}$ field is prescribed by the current density $\mathbf{J}$ in the loop, as given by the integral expression, the last of Eqs.(4.69), or by the inhomogenous wave equation, the fourth of Eqs.(4.75).

For a rigid closed current loop source $\nabla\cdot\mathbf{A} = 0$ and $\nabla\cdot\mathbf{N} = 0$; and the force on a moving charge q is given by Eq.(4.50). Moreover, in this simple case it may be assumed that no free unshielded charges occur; thus, the force on a moving detector charge q with the velocity $\mathbf{v}$ is given simply by Eq.(4.51). The rate that the force does work *on the field* $\mathbf{A}$ is then given by

$$\mathbf{v}\cdot\mathbf{F} = q\mathbf{v}\cdot\partial\mathbf{A}/\partial tc. \tag{4.98}$$

For a current density $\mathbf{J}$, where $q\mathbf{v} \rightarrow \mathbf{J}$, the rate that this force does work on the field per unit volume is then

$$dW/dt = \mathbf{J}\cdot\partial\mathbf{A}/\partial tc. \tag{4.99}$$

To obtain an expression for the conservation of energy the fourth of Eq.(4.75) may be multiplied by $(\partial\mathbf{A}/\partial t)/4\pi$, noting the vector identity (4.65), where for a closed current loop $\nabla\cdot\mathbf{A} = 0$, yields

$$(\partial\mathbf{A}/\partial t)\cdot\left[\nabla\times(\nabla\times\mathbf{A}) + \partial^2\mathbf{A}/\partial t^2c^2\right] = \mathbf{J}\cdot\partial\mathbf{A}/\partial tc. \tag{4.100}$$

Using the vector identity

$$(\partial\mathbf{A}/\partial t)\left[\nabla\times(\nabla\times\mathbf{A})\right] = -\nabla\cdot\left[(\partial\mathbf{A}/\partial t)\times(\nabla\times\mathbf{A})\right] + (\partial/\partial t)\left[(\nabla\times\mathbf{A})^2\right]/2, \tag{4.101}$$

then yields the conservation of energy as

$$\nabla\cdot\mathbf{S}_m + \partial E_m/\partial t = \mathbf{J}\cdot\partial\mathbf{A}/\partial tc, \tag{4.102}$$

where the wave energy flux $\mathbf{S}_m$, or Poyting's vector, and the wave energy density $E_m$ are given by

$$\mathbf{S}_m = -(\partial\mathbf{A}/\partial t)\times(\nabla\times\mathbf{A})/4\pi\,,$$
$$E_m = \left[(\partial\mathbf{A}/\partial tc)^2 + (\nabla\times\mathbf{A})^2\right]/8\pi\,, \tag{4.103}$$

(This result (4.103) would appear to be the Maxwell result, if $\Phi = 0$ and $\mathbf{E} = -\partial\mathbf{A}/\partial tc$ and $\mathbf{B} = \nabla\times\mathbf{A}$.)

For an $\mathbf{A}$ field only the force on a moving detector charge q is given by Eq.(4.51). The force on a stationary detector

charge q is in the direction of $\partial \mathbf{A}/\partial tc$, which is perpendicular to the Poynting vector, the first of Eqs.(4.103) When a force acts transversely to the direction of the wave propagation, or the direction of the energy flux, then the wave is defined as a transverse wave.

However, it should also be noted that the force acting on a moving charge given by $q\mathbf{v}\times(\nabla\times\mathbf{A})$, need not be perpendicular to the Poynting vector, the first of Eqs.(4.103). If $\mathbf{v}$ happens to be parallel to $\partial \mathbf{A}/\partial tc$, then the force is parallel to the Poynting vector, which defines a longitudinal wave. If $\mathbf{v}$ happens to be parallel to the Poynting's vector, then the force is perpendicular to the Poynting's vector, which defines again a transverse wave. The magnetic wave has, thus, both transverse and longitudinal properties. However, since a stationary detector charge represents the primary detection mode; the magnetic wave is best characterized as a *transverse wave*.

The transverse magnetic wave can be plane polarized. In particular, a plane wave solution to the homogeneous wave equation, the fourth of Eq.(4.75) and the vector identity (4.65), travelling in the z direction, can be obtained for the x component of $\mathbf{A}$ only; thus,

$$A_x = \sin(kz - \omega t), \tag{4.104}$$

where $\omega$ is the angular frequency and $k = 2\pi/\lambda$ is the propagation constant. In this case the curl of $\mathbf{A}$ has only a y component

$$\nabla\times\mathbf{A} = (\partial A/\partial z)\mathbf{e}_y = k\cos(kz - \omega t)\mathbf{e}_y. \tag{4.105}$$

The Poynting vector from the first of Eqs.(4.103) then has only a z component, given by

$$S_z = -(\partial A_x/\partial t)(\partial A_x/\partial z)/4\pi = (k\omega/4\pi)\cos^2(kz - \omega t) = E/c, \tag{4.106}$$

where the energy density $E$ is defined by the second of Eqs.(4.103) and $c = \omega/k$. This result (4.106) represents a plane polarized wave, polarized in the xz plane, propagating in the z direction with the velocity c. An independent plane polarized wave also propagating in the z direction with the velocity c, polarized in the yz plane with only a y component of $\mathbf{A}$ is also possible.



## 4.22 The Electromagnetic Wave

An unshielded charge distribution $\rho$ can give rise to waves that satisfy the inhomogeneous wave equation, the third of Eqs. (4.75) for $\Phi$. Since solutions to the wave equation, giving rise to waves, require $\Phi$ to be a function of the time; the source charge density $\rho$, that gives rise to the wave, must itself vary with the time, $\partial\rho/\partial t \neq 0$. This means that the equation of continuity (4.55) for the conservation of charge, involving $\partial\rho/\partial t$, must be considered. Since source currents cannot be shielded (unlike charges); a time changing charge density $\partial\rho/\partial t$ necessarily implies an associated source current density J, given by the equation of contiuity; thus,

$$\nabla\cdot\mathbf{J} = -\partial\rho/\partial t. \tag{4.107}$$

This result (4.107) in turn implies a necessary relationship between the magnetic vector potential $\mathbf{A}$, defined in terms of the current density J, the second of Eqs.(4.46), and the scalar potential $\Phi$, defined in terms of the charge density, the first of Eqs.(4.46). This coupling of the source charge density with the source current density gives rise to the "electromagnetic wave".

To derive an expression for the conservation of energy in this case the rate that the sources do work on the field per unit volume to generate the electromagnetic radiation field is

$$dW/dt = \mathbf{J}\cdot(\nabla\Phi + \partial\mathbf{A}/\partial tc) + \rho\partial\Phi/\partial t. \tag{4.108}$$

This result is the same as Eq.(4.99) with the added effect of the $\Phi$ field. It may be noted that the rate of increase of the potential energy of a single charge with the velocity $\mathbf{v}$ is given by

$$d(q\Phi)/dt = q\partial\Phi/\partial t + q\mathbf{v}\cdot\nabla\Phi. \tag{4.109}$$

For a distribution of charges this then becomes

$$\rho\partial\Phi/\partial t + \mathbf{J}\cdot\nabla\Phi, \tag{4.110}$$

which is the quantity added to Eq.(4.99) to obtain Eq.(4.108). (The rate that the static charge distribution $\rho$ does work per unit volume on the time changing scalar potential, $\rho\partial\Phi/\partial t$, is neglected in the Maxwell theory.)

Mathematically the electromagnetic radiation field can be

separated into two parts, an **A** portion and a $\Phi$ portion. Physically these two portions are, of course, inseparable. The **A** portion is given by the inhomogeneous wave equation for **A**, the fourth of Eqs.(4.74) and (4.65), which may be written as

$$\nabla\times(\nabla\times\mathbf{A}) + \nabla\partial\Phi/\partial tc + \partial^2\mathbf{A}/\partial t^2c^2 = 4\pi\,\mathbf{J}/c. \qquad (4.111)$$

It is convenient to introduce the "electric field" $\mathbf{E} = -\nabla\Phi - \partial\mathbf{A}/\partial tc$ and a "magnetic field" $\mathbf{B} = \nabla\times\mathbf{A}$, as already defined by Eqs.(4.53). Then a *portion* of the rate work is done on the field, as given by Eq.(4.108), becomes

$$\mathbf{J}\cdot(\nabla\Phi + \partial\mathbf{A}/\partial tc) = \mathbf{J}\cdot\mathbf{E}. \qquad (4.112)$$

Introducing the definitions (4.53), the inhomogeneous wave equation for **A**, Eq.(4.111), may then be written as

$$\nabla\times\mathbf{B} - \partial\mathbf{E}/\partial tc = 4\pi\mathbf{J}/c, \qquad (4.113)$$

(the second Maxwell equation).

Multiplying Eq.(4.113) by **E**, using the vector identity

$$\mathbf{E}\cdot(\nabla\times\mathbf{B}) = -\nabla\cdot(\mathbf{E}\times\mathbf{B}) + \mathbf{B}\cdot(\nabla\times\mathbf{E}), \qquad (4.114)$$

and noting from the definition of **E** and **B** that

$$\nabla\times\mathbf{E} = -\partial\mathbf{B}/\partial tc, \qquad (4.115)$$

(the first Maxwell equation), the **A** portion of the field yields

$$\nabla\cdot\mathbf{S}_p + \partial E_p/\partial t = -\mathbf{J}\cdot\mathbf{E}, \qquad (4.116)$$

where $\mathbf{S}_p$ is the traditional Poynting's vector and $E_p$ is the traditional energy density of the Maxwell theory, given by

$$\mathbf{S}_p = c(\mathbf{E}\times\mathbf{B})/4\pi, \quad \text{and} \quad E_p = (\mathbf{E}^2 + \mathbf{B}^2)/8\pi. \qquad (4.117)$$

This partial result (4.116) and (4.117), which is the Poynting's theorem, cannot represent the conservation of energy in general; because the physically necessary $\Phi$ portion of the field is not included. To conserve energy the *entire* field energy must be included. The Poynting's theorem and the Maxwell theory for radiation are thus not physically correct in general. They are, however, physically correct for the special case of a transverse magnetic wave, Eqs.(4.102) and (4.103), where no $\Phi$ portion of the field exists.



To include the $\Phi$ portion the third of Eqs.(4.75) for $\Phi$ may be multiplied by $\partial\Phi/\partial t$ to yield

$$\nabla\cdot\mathbf{S}_s + \partial E_s/\partial t = \rho\,\partial\Phi/\partial t, \qquad (4.118)$$

where

$$\mathbf{S}_s = -(\nabla\Phi\,\partial\Phi/\partial tc)/4\pi, \quad \text{and} \quad E_s = \left[(\nabla\Phi)^2 + (\partial\Phi/\partial tc)^2\right]/8\pi, \qquad (4.119)$$

and where $\rho\,\partial\Phi/\partial t$ is the $\Phi$ portion of the rate of work per unit volume on the field, as given by Eq.(4.108).

Including the $\Phi$ portion of the field, as given by Eqs.(4.118) and (4.119), energy can be conserved in terms of the total energy flux, $\mathbf{S} = \mathbf{S}_p + \mathbf{S}_s$, and the total energy density, $E = E_p + E_s$; thus,

$$\nabla\cdot\mathbf{S} + \partial E/\partial t = \mathbf{J}\cdot\left[\nabla\Phi + \partial\mathbf{J}/\partial tc\right] + \rho\,\partial\Phi/\partial t, \qquad (4.120)$$

where

$$\mathbf{S} = -\left[(\nabla\Phi + \partial\mathbf{A}/\partial tc)\times(\nabla\times\mathbf{A}) + \nabla\Phi\,\partial\Phi/\partial t\right]/4\pi,$$
$$E = \left[2(\nabla\Phi)^2 + (\partial\Phi/\partial tc)^2 + 2\nabla\Phi\cdot(\partial\mathbf{A}/\partial tc) + (\partial\mathbf{A}/\partial tc)^2 + (\nabla\times\mathbf{A})^2\right]/8\pi, \qquad (4.121)$$

where $\Phi$ and **A** are solutions to the wave equations (4.75).

The **A** portion of the radiation field may be characterized as yielding essentially transverse waves; because the force on a stationary charge is transverse to $\mathbf{S}_p$. The $\Phi$ portion of the radiation field may be characterized as yielding longitudinal waves; because the force on a stationary detector charge is parallel to $\mathbf{S}_s$, the first of Eqs.(4.119).

Electromagnetic waves, being produced by unshielded moving charges, should be the radiation produced by atoms and molecules. Thus, light should be an electromagnetic wave with both transverse and longitudinal properties. However, from the fact that light can be completely plane polarized would seem to indicate that atomic sources generate only transverse waves. Thus, do atomic sources radiate only in the transverse magnetic mode, as discussed in Section 4.21 above?

## 4.23 Longitudinal Electrodynamic Waves

Although a distribution of moving unshielded charges $\rho$ are always accompanied by an unavoidable current density **J**; it may be that the current effects, giving rise to the magnetic vector

potential **A** may be small and may be, therefore, neglected for some situations. If the vector potential **A** can be neglected, then a longitudinal electrodynamic wave defined by the scalar potential $\Phi$ field alone, that satisfies the third of Eqs.(4.75) and that gives rise to the energy flux $S_s$ and density $E_s$, defined by Eqs.(4.119), may be regarded as existing independently. The mere fact that $\Phi$ is a solution to the scalar wave equation, the third of Eqs. (4.75) is sufficient itself to indicate that longitudinal electrodynamic waves must, in fact, exist (even if not independent of an **A** field).

Energy can be transmitted from one plate to the other plate across the empty gap between the plates of a parallel plate condenser. When one plate is driven sinusoidally in time to produce a time varying surface charge density source on the plate and a time varying electric scalar potential $\Phi$ is created between the plates, a corresponding opposite surface charge density is *induced* on the other plate, that may be taken to be the detector plate. Energy is observed to be transported from the source plate to the detector plate across the empty gap between the plates. The only electrodynamic force field between the plates that acts on a stationary charge, that does not depend upon current sources, as given by Eq.(4.48), is

$$\mathbf{F}/q = \mathbf{E} = -\nabla\Phi, \tag{4.22}$$

which is perpendicular to the plates of the condenser. In order to transmit energy across the empty gap between the condenser plates a *radiation* field that carries a net amount of energy *must* be present. This radiation field can only be a longitudinal wave, the energy transported being in the same direction as the force field.

Generally the plates of a condenser are very close together; so there is a reciprocal action of the induced charges on the second plate back on the first plate. Thus, in general. the radiation from the first plate to the second plate is accompanied by a reverse radiation back from the second plate to the first plate. Generally, at any instant the **E** field is more-or-less identical at the surface of both plates. In general the separation distance D between the



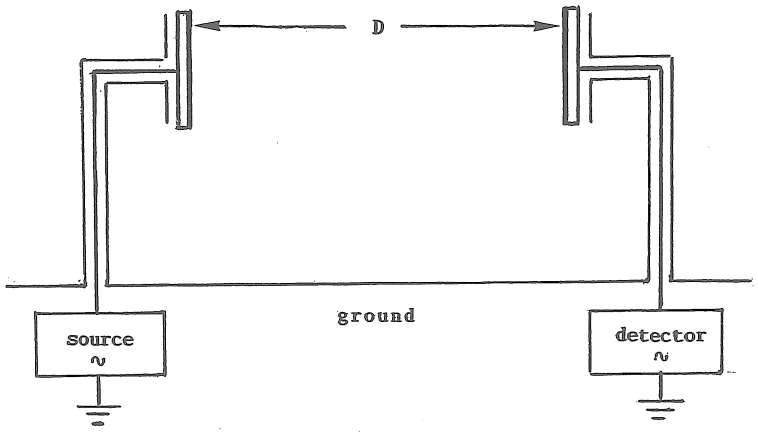



Fig. 4.1 Monstein's setup to detect logitudinal electrodynamic waves for $D > \lambda = c/f$.

plates is much smaller than a wavelength of the radiating wave; so the radiation is not apparent.

To demonstrate the longitudinal wave between the plates of a parallel plate condenser it is only necessary to make the wavelength smaller than the separation distance between the plates, and to dirve one plate as the source and allow the other plate to act as the detector, or receiver, as indicated in Fig. 4.1. In this case the **E** field will not in general be the same on the two plates at any instant.

Christian Monstein (in a private communicate) reports doing this experiment with the plates farther apart than a wavelength with a positive result. In addition, by using two source plates, he was able to demonstrate Young's double pinhole interference, when the receptor plate scanned the field along a line parallel to the line joining the two source plates. His preliminary observations, thus, confirm the existence of longitudinal electrodynamic waves.

CHAPTER 5

# INDUCTION

Induction involves electrodynamic phenomena associated with time changing currents or accelerating charges. In particular, this Chapter 5 is concerned with the force of induction F on a charge q with a velocity v given by

$$F = - qdA/dtc = - q\partial A/\partial tc - q(v\cdot\nabla)A/c - q(A\cdot\nabla)v/c. \qquad (5.1)$$

where A is the magnetic vector potential.

The Wesley field theory, discussed in Chapter 4, involves the partial time derivative $\partial A/\partial t$; because a field theory involves the properties associated with a particular fixed point in absolute space. In contrast, induction involves the fields and forces acting on a charge that is moving with the velocity v. Thus, the Wesley field theory does not yield the force of induction; unless the replacement

$$\partial A/\partial t \rightarrow dA/dt, \qquad (5.2)$$

is made.

## 5.1 Induction Is a Relativity Theory

Induction involves only slowly varying effects, where no radiation occurs. Thus, action-at-a-distance and relativity are valid. Newton's third law is applicable between the "source" charges and the "detector" charges. Symmetry exists between source and detector; they are interchangeable in principle.

It is important to note that, for a charge q with an absolute velocity v and an absolute acceleration a and for a charge q' with an absolute velocity v' and an absolute acceleration a', the simple differences v - v' and a - a' are not the appropriate "relative"



velocity and "relative" acceleration between two charges that can be used in a relativity theory. In particular, a physical interaction between two charges, as though the rest of the universe were otherwise empty, can only be along the line joining the two charges. The "relative" velocity, that can be detected by the two charges only, independent of the rest of the universe, is only the component of the velocity difference v - v' along the line joining the two charges, given by R = r - r'. Thus, the "relative" velocity becomes

$$V(\text{relative}) = (dR/dt)(R/R) = (V\cdot R)R/R^2 = V_{\parallel}\ , \qquad (5.3)$$

where V = v - v' is the absolute velocity difference, and $V_{\parallel}$ is the component of V parallel to R.

Similarly the appropriate "relative" acceleration is defined by

$$A(\text{relative}) = (d^2R/dt^2)(R/R) = \left[V^2 - (V\cdot R)^2/R^2 + A\cdot R\right]R/R^2$$
$$= (V_{\perp}^2 + A\cdot R)R/R^2, \qquad (5.4)$$

where $V_{\perp}$ is the component of V perpendicular to R, and A = a - a' is the difference in the individual absolute accelerations.

It may be noted that even for two charges, each moving with individual constant rectilinear absolute velocities v and v' and with a = a' = 0, the "relative" velocity, defined by Eq.(5.3), need not be constant in time. It remains along R and not along V. In this case the "relative" acceleration, defined by Eq.(5.4), need not be zero; the "centrifugal" term $V_{\perp}^2\, R/R^2$ remains. And it is along R and not along A. The relative kinematics necessary for the interaction of two bodies, independent of the rest of the universe, is, thus, complicated and not immediately self evident.

## 5.2 The Law of Induction Derived from the Weber Potential

The electrodyanmics of Weber (1846, 1848, 1893) that is valid for slowly varying effects, for slowly moving charges, and for no radiation is the appropriate theory for induction. The Weber potential, Eq.(4.5), for charge q at r with velocity v and q' at r', neglecting the self velocity squared terms, that have never been observed, and for no electrostatic field, is given by

$$W = qq'(v\cdot R)(v'\cdot R)/c^2R^3. \qquad (5.5)$$

Induction generally involves closed rigid current loop sources; so for charge q in the field of distributed q' forming closed current loops, the Weber potential from Eq.(5.5) becomes

$$W = qIv\cdot\oint R(R\,ds')/c^2R^3 = qIv\cdot\oint ds'/c^2R = qv\cdot A/c. \tag{5.6}$$

(This actual potential, Eq.(5.6) is the negative of the orthodox pseudo-potential contrived to yield the Lorentz force from an arbitrary Lagrangian formalism (Goldstein (1950).) The rate that energy is lost to do work on the charge q is then

$$-dW/dt = -qv\cdot dA/dtc = v\cdot F, \tag{5.7}$$

which then yields the law of induction, Eq.(5.1), for the force of induction F for the case of closed current loop sources and a constant charge q velocity v.

## 5.3 Transformer Induction

For the general case of closed current loop sources $\nabla\cdot A = 0$; since from the definition $A = \int J'/cR$ for a closed tube of flow

$$c\nabla\cdot A = -\int J'\cdot R/R^3 = I\oint ds'(d/ds)(1/R) = I/R\Big|_0^\circ = 0. \tag{5.8}$$

For the detector, or observer, charge q stationary at r the force on the charge according to Eq.(5.1) is given simply by

$$F = -q\,\partial A/\partial tc, \tag{5.9}$$

the case for transformer induction. This result (5.9) means that the field A must be changing as a function of time at the position of the charge q situated at r. This result (5.9) is sufficient to yield the emf (electromotive force) induced in the secondary winding of a transformer. In particular, the emf induced in a closed loop is given by integrating the force per unit charge around the loop; thus, from Eq.(5.9)

$$\text{emf} = \oint (F/q)\cdot ds' = -\oint(\partial A/\partial tc)\cdot ds'. \tag{5.10}$$

To illustrate the principles the elementary case of an infinitely long primary circular cylindrical solenoid of radius $a$ with a single loop cocentric outer secondary coil of radius $r >> a$ may be considered. The current in the primary per unit length in in terms of cartesian coordinates is given by



$$\eta e_\phi = \eta(-\sin\phi' e_x + \cos\phi' e_y), \tag{5.11}$$

where, due to the circular symmetry, the orientation of the x and y axis may be chosen arbitrarily in the xy-plane. From its definition

$$A = \int J'/cR = (\eta a/c)\int_0^{2\pi} d\phi' \int_{-\infty}^{\infty} dz'(-\sin\phi' e_x + \cos\phi' e_y)\Big/ \sqrt{r^2 + a^2 - 2ra\cos(\phi - \phi') + (z - z')^2}. \tag{5.12}$$

Choosing the point of observation in the xz-plane, where $\phi = 0$, the x component of A then vanishes due to the odd integrand. The y component is then simply the $\phi$ component of A. For the present case of interest, where $r >> a$, Eq.(5.12) then gives

$$A_\phi = (\eta a/c)\int_{-\infty}^{\infty} dz' \int_0^{2\pi} d\phi'(\cos\phi'/R + a\cos^2\phi'/R^3), \tag{5.13}$$

where here

$$R^2 = r^2 + (z - z')^2. \tag{5.14}$$

Performing the integrations then yields the well known result

$$A_\phi = 2\pi\eta a^2/cr, \tag{5.15}$$

for $r > a$.

For the current per unit length $\eta$ varying with time the force on a charge q at the radial distance r, as given by Eq.(5.9), becomes

$$F_\phi = -(2\pi q a^2/c^2 r)\,\partial\eta/\partial t. \tag{5.16}$$

The induced emf in the single loop secondary is then given by

$$\text{emf} = \int_0^{2\pi}(F_\phi/q)r\,d\phi' = (4\pi^2 a^2/c^2)(\partial\eta/\partial t), \tag{5.17}$$

which is the desired result.

Transformer induction can, thus, always be predicted in terms of the time changing magnetic vector potential A as the true physical cause for the induced emf. A magnetic B field that is zero in the secondary wire loop, $B = \nabla\times A = 0$, cannot account for the observed transformer induction.

## 5.4 Faraday's Law Is Wrong; Changing Magnetic Flux Does Not Cause Induction

Superficially Faraday's law of electromagnetic induction appears to be correct; because the equality between the emf induced in a closed loop and the rate of change of the magnetic flux through the

loop is, in fact, correct for transformer induction with static geometry. But it is wrong as a *physical* law; because the changing magnetic flux does not *cause* the induced emf in the loop. It is the time changing magnetic vector potential A field in the secondary wire that creates the force on the carrier electrons, that *causes* the emf in the loop (as indicated in the previous Section 5.3).

The same time changing potential field A also exists in the empty space within the loop, which then also produces the time rate of change of the magnetic B flux through the loop. This concomitant effect has, of course, nothing at all to do with the *cause* that produces the induced emf. The Faraday "law" is, thus, merely a relationship between two concomitant *effects*, both of which are produced by the same *cause*, the time changing A field.

It may be readily shown that the time changing A field, that produces the emf in the secondary wire loop, also causes the time changing magnetic B flux through the empty space enclosed by the loop. Thus, applying Stokes theorem to the right side of Eq.(5.10) yields

$$- \oint ( \partial A/\partial tc)\, ds = - \int_S da\, n\cdot( \nabla \times \partial A/\partial tc), \qquad (5.18)$$

where da is an element of the surface S bounded by the closed wire loop and n is a unit normal to the surface. Interchanging the order of operations and introducing the B field, $B = \nabla \times A$, Eq.(5.18) yields

$$- \oint (\partial A/\partial tc)\, ds = - ( \partial/ \partial tc) \int_S da(B\cdot n) = - \partial\Phi/ \partial tc, \qquad (5.19)$$

where $\Phi$ is the magnetic B flux through the loop. This result then proves that the time changing A field causes both the induced emf as well as the changing magnetic B flux through the loop; which then gives rise to the so called "Faraday law of electromagnetic induction"

$$emf = - \partial\Phi/\partial tc. \qquad (5.20)$$

This result (5.20) is precisely the same result (4.16) that is derived from the Weber theory. However, the derivation for the Weber theory involves the Weber relative acceleration $(R\cdot\partial J'/\partial t)R/R^2$; whereas, here the Weber relative acceleration has been replaced simply by the acceleration $\partial J'/\partial t$ itself. The two results (4.16) and (5.20) are the same for this special case of an emf induced



in a rigid stationary closed loop, as is involved in transformer induction.

Considering the example of transformer induction presented in the previous Section 5.3, the magnetic B field is zero everywhere outside of the inifinitely long solenoid; thus,

$$B = \nabla \times A = e_z\, (1/r)\, \partial(rA_\phi)/\, \partial r = 0, \qquad (5.21)$$

where $A_\phi$ equals a constant times (1/r), as given by Eq.(5.15). The magnetic B field is, thus, zero inside the metal wire of the secondary loop of the transformer. The B field is also zero outside of the primary windings of a toroidal transformer. And in general the magnetic B field is zero (or negligibly small due to leakage) in the region of the secondary windings of an ordinary transformer. The force driving the carrier electrons in the secondary metal wire windings of a transformer that produces the emf cannot be caused by a time changing magnetic B field, the B field being zero or negligibly small

The changing magnetic B flux prescribed by the Faraday "law", Eq.(5.20), occurs in a region removed from the location of the emf inside the wires of the secondary windings. A "cause" at one location in space cannot produce an "effect" at some different location without any physical connection or mechanism being involved to transport the action between the two locations. The Faraday "law" is clearly wrong. In contrast, the more physically real magnetic vector potential A is not zero, nor negligible, in the secondary windings of a transformer. The time varying A field can, thus, "cause" the induced emf in the secondary windings.

Considering the example of transformer induction presented in the previous Section 5.3, the magnetic vector potential A inside the infinitely long solenoid is given by

$$A_\phi = 2\pi\eta\, r/c, \qquad (5.22)$$

for $r < a$. This result (5.22) is continuous with A for $r > a$, Eq.(5.15); and it satisfies the required differential equation, $\nabla \times ( \nabla \times A) = 0$. Inside the infinitely long solenoid the magnetic B field, as given by Eqs.(5.21) and (5.22), becomes

$$B_z = 4\pi\eta/c. \qquad (5.23)$$

For this example the time changing magnetic flux inside the primary infinitely long solenoid is then

$$\partial\Phi/\partial tc = \pi a^2 \partial B_z/\partial tc = (4\pi^2 a^2/c^2)\,\partial\eta/\partial t. \qquad (5.24)$$

Comparing the two consequences, or two effects, of the time changing A field, Eq.(5.24) and (5.17), Faraday's "law", Eq.(5.20), is seen to be satisfied for this simplest example of transformer induction presented in the previous Section 5.3.

## 5.5 Induction in a Stationary Conductor Not Forming a Closed Loop

It should not be assumed that the difficulty with Faraday's "law" is merely one of semantics: Does the equality of Eq.(5.20) mean a relation between "cause" and "effect"; or merely a relation between two "effects" produced by a common "cause"? As generally interpreted, it is suppose to be a *cause and effect* relationship. It is suppose to account for *all* induction phenomena in stationary conductors. Practically all electrical engineers and physicists still believe that a time changing magnetic B field is necessary to cause induction, which is not true, as already proved above. Faraday's "law" is often elevated to the "flux rule", that is supposed to somehow account for all induction phenomena.

The absurdity of the "flux rule" and, thus, Faraday's "law" is dramatically illustrated by the Tilly (1968) test, using the circuit diagrammed in Fig. 5.1. When the switch is moved from

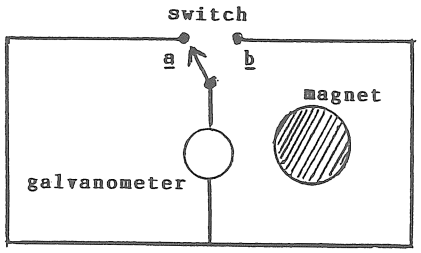



Fig. 5.1 The Tilley test: When the switch is moved suddenly from a to b the large sudden increase in the flux through the galvanometer circuit produces no emf, which violates the "flux rule" and Faraday's "law".

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position a to position b the magnetic B flux through the galvanometer circuit increases rapidly from zero to a large amount produced by the magnet indicated; but no emf is registered by the galvanometer. This null result violates the "flux rule" and thus Faraday's "law".

In terms of the true explanation, Eqs.(5.9) and (5.10), there is no time rate of change in the magnetic vector potential A anywhere in the wires of the entire setup: so, clearly, no emf can be induced anywhere.

If a condenser is placed within the single wire loop of the simple example of a transformer discussed in Section 5.3, then the loop is interrupted by a gap. Since no completely closed wire loop exists; it is impossible to define an area that is enclosed by a loop; and no magnetic B flux can be defined and thus exist. Since $\partial\Phi/\partial t = 0$; no emf should occur, according to the "flux rule" and according to Faraday's "law". Never-the-less, a potential difference across the condenser will be observed when a time changing current is fed into the infinite primary solenoid. This potential difference can be readily predicted by the true explanation for induced transformer induction, Eq.(5.9), that requires no closed wire loop. Assuming the gap between the condenser plates is negligible, the potential across the condenser will be given by Eq.(5.17).

In an attempt to rescue the "flux rule" and Faraday's "law" it is usually claimed that the loop need not be entirely a closed wire loop; the loop may be completed by an arbitrary imaginary mathematical path, if a gap occurs, such as in a condenser. But such arbitrary imaginary mathematical closed paths have no place in an empirical science. For example, if the arbitrary mathematical path between the two plates of the condenser is chosen to go back around the primary solenoid, then a zero induced potential difference should be observed across the condenser, which then contradicts the "flux rule" with arbitrary imaginary closed paths. To eliminate this added difficulty it is necessary to add still another ad hoc hypothesis: The arbitrary imaginary mathematical path must enclose the primary solenoid just once (or an odd number of times). But this is still not sufficient to resolve the difficulties created by introducing the notion of fictitious arbitrary closed mathematical paths; as proved by the following example:

The induced emf. or potential difference, across a straight portion of wire along the y axis from - L/2 to + L/2 due to time changing currents in two infinitely long thin solenoids at x = + b and - b with counter directional windings, as shown in Fig. 5.2, may be considered. The emf is given by integrating Eq.(5.9) from - L/2 to + L/2, where the force of induction for each solenoid is given by Eq.(5.16). In terms of cartesian components the force per unit charge due to both solenoids becomes

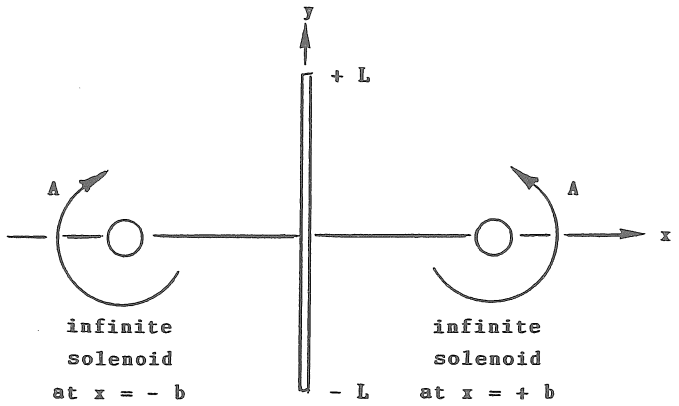


Fig. 5.2 Diagram for the induced emf in a straight wire from y = L/2 to + L/2 due to two infinite solenoids at x= + b and - b, oppositely wound.

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$$\mathbf{F}/q = (2bK/Q^4)\left[2xy\mathbf{e}_x + (b^2 - x^2 + y^2)\mathbf{e}_y\right], \tag{5.25}$$

where

$$K = (2\pi a^2/c^2)\,\partial\eta/\partial t, \qquad Q^4 = (b^2 + x^2 + y^2)^2 - 4b^2x^2. \tag{5.26}$$

The line integral, Eq.(5.10), from y = - L/2 to + L/2 along the wire, where x = 0, then becomes

$$\text{emf} = 2bK\int_{-L/2}^{+L/2} dy/(b^2 + y^2) = 4K\tan^{-1}(L/b). \tag{5.27}$$

When the solenoids are driven with a sinusoidal current in phase this potential difference, Eq.(5.27), can, in principle, be measured by a sensitive electrometer or electroscope that is activated by an oscillating excess charge induced on one end of the wire.



If the emf is computed using the "flux rule" involving a hypothetical closed path, then the predicted results depends upon the arbitrary mathematical path chosen; and it need not yield the desired emf given by Eq.(5.27). If, for example, the closed path is chosen to pass around either one of the two solenoids from y = + L/2 to y = - L/2, then from Eqs.(5.20) and (5.17)

$$\text{emf by "flux rule"} = (4\eta^2 a^2/c^2)\,\partial\eta/\partial t. \tag{5.28}$$

This result does not equal the desired induced potential between the ends of the straight wire, as given by Eq.(5.27). Moreover, this result assumes that the other solenoid, not encircled can have no effect on the induced emf between the ends of the straight wire. This incorrect result (5.28), is not a function of the length of the wire L, as it should be, according to the correct result (5.27). If the ends of the straight wire were closed by a loop in the yz-plane, the magnetic B flux through this loop would be zero; and the "flux rule" would predict no emf induced in the wire. The "flux rule" with arbitrary closed mathematical paths can yield no unambiguous results in agreement with actual observations in general.

## 5.6 The Hooper-Monstein Experiment

Hooper (1974) and Monstein (1992) arranged two identical magnets of opposite polarity equidistant on opposite sides of a straight wire, as shown in Fig. 5.3 (see also Wesley 1996f). When the magnets are made to approach (or recede) with the identical speed v, an emf is induced in the wire, as is evidenced by an ammeter in the closed loop indicated.

The force of induction, as given by Eq.(5.9), differs from zero only in the straight wire portion of the loop. The magnetic potential A lines for the bar magnets form circles about the axes of the magnets (precisely as for a cylindrical solenoid); so the z component of A and $\partial A/\partial t$ are zero in the Hooper-Monstein setup; and no induction can occur in the vertical leads from the ends of the straight wire, shown in Fig. 5.3. The branch of the circuit containing the ammeter is chosen at a large enough value of z that the A field produced by the magnets of finite length is zero.

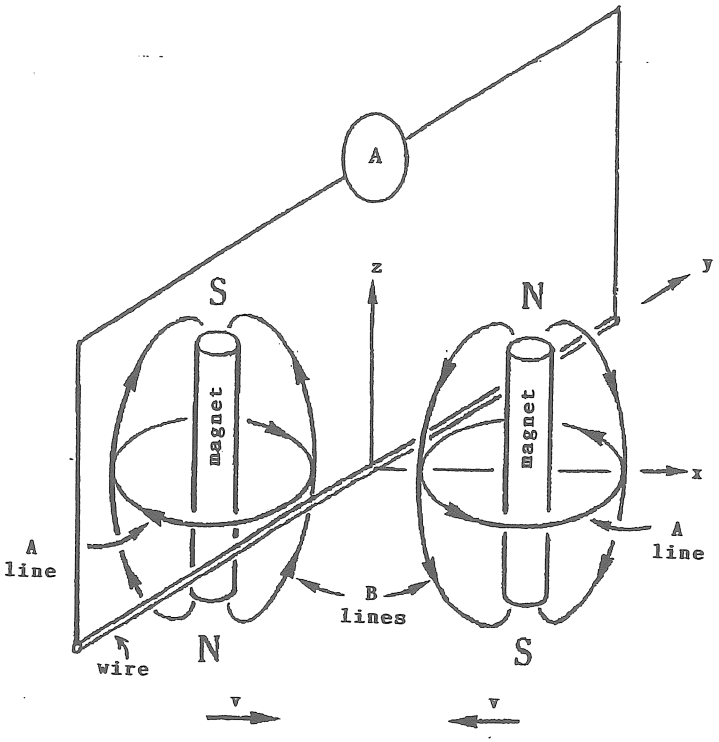


Fig. 5.3 The Hopper-Monstein setup demonstrating induction in a wire when two equidistant magnets of opposite polarity are made to approach (or recede from) the wire symmetrically with the speed v. The magnetic B field remains zero in the wire; but the magnetic potential A field is nonzero and increases (or decreases).

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The two identical magnets of opposite polarity equidistant from the wire yield a zero B field along the straight wire in which the induction occurs. In this way it is demonstrated that the magnetic B field has nothing to do with the observed induction (as already demonstrated by the obvious lack of a B field in the outer secondary winding of a toroidal transformer). The magnetic B fields produced by the two magnets subtract to yield zero along the wire; while the A fields of the two magnets add along the wire, doubling the current induced.



Stokes theorem can be applied to a closed wire loop to prove that the net emf induced around the loop always equals the time rate of change of the magnetic B flux through the loop, as proved by Eqs.(5.9) and (5.19). The resulting changing magnetic B flux, $-\partial\Phi/\partial tc$, does not tell one *where* in the wire loop the induced emf occurs. The changing magnetic B flux is, thus, merely a concomitant variation, that *always* occurs in a loop where induction occurs, but that has nothing to do with the induction produced. Just because the cock *always* crows every morning does not mean that the cock makes the sun rise.

To verify the fact that the magnetic B flux through the loop has nothing to do with the induction that occurs a variety of methods can be employed. Only the straight wire need be used, thereby avoiding the need for a closed loop to detect the induction. The potential difference induced between the ends of the wire and ground can be registered with a sensitive electrometer or electroscope, so that no current need be produced to register the induction. The localized seat of the emf in the straight wire portion of the loop can be demonstrated using the brilliant, but elementary, method of Francisco Müller (1987), as presented in the following Section 5.7.

The magnitude of the induced emf in the Hooper-Monstein experiment can be derived by considering the effect of only one of the two moving magnets. The effect of both magnets is simply doubled. Considering solenoids equivalent to the magnets, the potential A produced by a solenoid of radius $a$ of finite length N with its axis in the direction centered on the x axis at $x = b$ for a point of observation with a radial position $r > a$ is given by Eq.(5.13), where the z integration is taken from $-N/2$ to $+N/2$, is given by

$$A_\phi = (\pi\eta a^2/cr)\left[(z + N/2)/\sqrt{\xi^2 + Nz} - (z - N/2)/\sqrt{\xi^2 - Nz}\right], \quad (5.29)$$

where

$$r^2 = (x - b)^2 + y^2 \qquad \xi^2 = r^2 + z^2 + N^2/4. \quad (5.30)$$

Choosing the case where

$$N^2/4 \gg b^2 + L^2/4 > r^2, \quad (5.31)$$

where the straight wire of length L is taken along the y axis from

$-L/2$ to $+L/2$, the A field of interest is the y component of A in the xz-plane, which from Eqs.(5.29), (5.30). and (5.31) or from Eq.(5.15), is given approximately by

$$A_y = 2\pi\eta a^2 (x - b)\Big/\Big[(x - b)^2 + y^2\Big]. \tag{5.32}$$

The force of induction from Eq.(5.9) in the wire along the y axis is then

$$F_y/q = -\,\partial A_y/\partial tc = (2\pi\eta a^2 v/c^2)(y^2 - b^2)\Big/(b^2 + y^2)^2, \tag{5.33}$$

when the magnet is moved with the speed $v = db/dt$ in the positive x direction. The emf from $y = -L/2$ to $+L/2$ is then given by

$$\begin{aligned} \text{emf} &= \int_{-L/2}^{+L/2} (F_y/q)dy = (2\pi\eta a^2 v)c^2) \int_{-L/2}^{+L/2} dy(y^2 - b^2)\Big/(y^2 + b^2)^2 \\ &= (\pi\eta a^2 v/c^2)\Big[\tan^{-1}(y/b) - by/(y^2 + b^2)\Big] \end{aligned} \tag{5.34}$$

Since b may be chosen much smaller than L; the second term in the brackets on the right may be neglected; so $\tan^{-1}(L/b) = \pi/2$. For the choice of parameters such that

$$N >> L >> b > a \tag{5.35}$$

the induced emf in the wire, and consequently in the entire loop, as indicated in Fig. 5.3, that is produced by *two* oppositely oriented solenoids (or magnets) moving with the common speed v away from the wire is given by

$$\text{emf} = 2\pi^2\eta a^2/c^2 \tag{5.36}$$

This is the potential induced in the entire closed loop indicated in Fig. 5.3; since no emf is induced in the other portions of the closed circuit.

When two identical magnets of pole strengths $p = \pi\eta a^2/c$. are used instead of solenoids, the emf is given by

$$\text{emf} = 2\pi pv/c, \tag{5.37}$$

where the parameters are chosen according to Eq.(5.31) and where the circuit is completed as shown in Fig. 5.3.

This theoretical result (5.36) or (5.37), which is derived in terms of the driving force, $-q\partial A_y/\partial tc$, on the carrier electrons in the straight wire *only*, can be compared with *quantitative* laboratory measurements to demonstrate the fact that the *cause* of induction is the force of induction, as given by Eq.(5.9) in the straight wire only and not the time changing magnetic B flux through the entire detection loop.



## 5.7 Müller's Method to Localize the Seat of Induction

Francisco Müller (1987) devised a brilliant, but elementary, method for determining the seat of emf in a closed loop. To decide whether the seat of emf is $E_1$ or $E_2$ in the circuit shown in Fig. 5.4

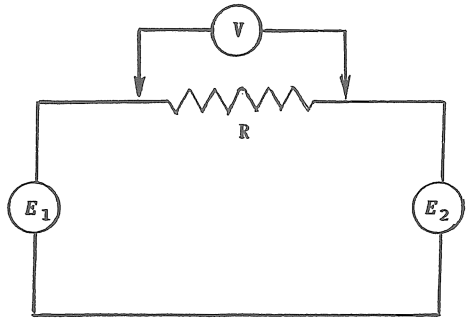



Fig. 5.4 Two possible seats of the emf registered by the voltmeter.

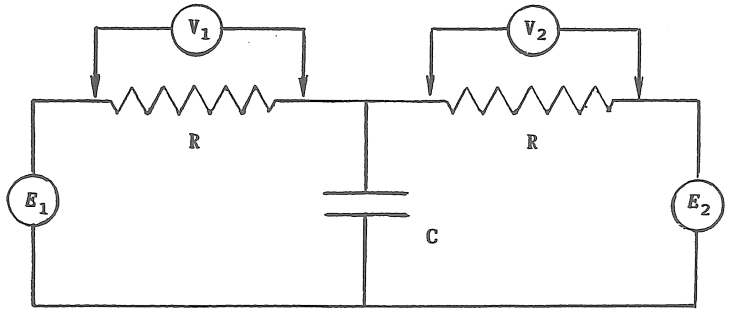



Fig. 5.5 Müller's circuit to decide which of the two possible sources, $E_1$ or $E_2$, is the true source of the observed emf.

a condenser may be introduced to yield the network shown in Fig. 5.5. The actual seat of the emf can be determined by changing both $E_1$ and $E_2$ rapidly simultaneously. The actual seat of emf will then be registered by a similar time changing voltage on the voltmeter on the same side of the circuit as the seat of emf. And no changing voltage will be registered on the other voltmeter on the side where the emf is zero. Thus, if $E_1$ is the seat, then $|V_1| \neq 0$ and $|V_2| = 0$; and, if $E_2$ is the seat then $|V_2| \neq 0$ and $|V_1| = 0$.

This result may be seen by applying Kirchhoff's rules to the network shown in Fig. 5.5; thus,

$$E_1 = RdQ_1/dt + C(Q_1 - Q_2), \qquad E_2 = RdQ_2/dt + C(Q_2 - Q_1), \tag{5.38}$$

where $Q_1$ is the charge flowing through $E_1$ and $Q_2$ that flowing through $E_2$. Eliminating $Q_2$ between these two Eqs.(5.38) and letting $V_1 = RdQ_1/dt$, then yields

$$(C/R)(E_1 + E_2 - 2V_1) + d(E_1 - V_1)/dt = 0. \tag{5.39}$$

Driving the sources of emf with the angular frequency $\omega$, the first term on the left of Eq.(5.39) may be neglected when $C/R\omega$ is chosen so that $C/R\omega \ll 1$, This then means (apart from a possible phase difference) that

$$|V_1| \simeq |E_1|. \tag{5.40}$$

Similarly, eliminating $Q_1$ between Eqs.(5.38) yields

$$|V_2| \simeq |E_2|. \tag{5.41}$$

Thus, if $|V_1| \neq 0$ and $|V_2| = 0$, then $E_1 \neq 0$ and $E_2 = 0$; and vice versa if $|V_2| \neq 0$. (If both $V_1$ and $V_2$ are different from zero, then, of course, both $E_1$ and $E_2$ contribute to the induction.)

The Müller method may be applied to the Hooper–Monstein experiment to demonstrate the fact that the emf is induced *only* in the straight wire by using the circuit illustrated in Fig. 5.6. A rapid movement of the solenoids, or magnets, toward or away from the wire yields $|V_1| > 0$; while $V_2$ remains zero. In the original closed circuit, illustrated in Fig. 5.6 as abcdef and back to a it is possible that an emf $E_1$ is induced from f to abc; while another emf $E_2$ is induced in the portion cde to f. When the magnets are



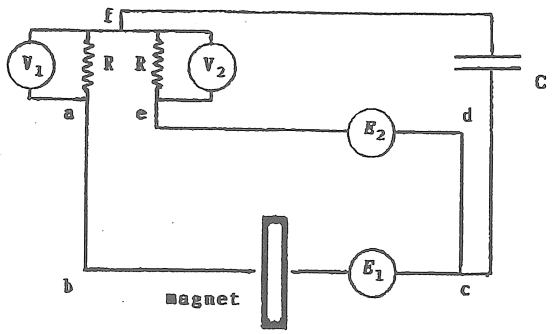



Fig. 5.6 Circuit for the Hooper–Monstein experiment to demonstrate the fact that the observed emf is induced in the straight wire from b to c and not in the remainder of the circuit.

moved rapidly and $|V_1| > 0$, while $V_2 = 0$ it means that the emf must be produced in the portion of the circuit from f to abc and that no emf is induced from c to def. This means that $E_2 = 0$ and no emf is induced from c to d. By symmetry it may then be concluded that no emf is induced from a to b. Consequently, this result demonstrates the fact that the emf can only be induced in the straight wire portion from b to c, yielding $E_1$.

Since the Müller method allows the localized seat of an emf to be determined; and since it is thereby empirically established that emf's are in general, in fact, localized (See Section 5.11b below concerning Müller's observations of localized unipolar induction); an entire current loop is not required for induction nor a B flux through such a loop. The localization of induction, thus, proves the Faraday law of electromagnetic induction wrong; a time changing magnetic B field through an entire closed loop does not *cause* induction.

## 5.8 Time Rate of Change of a Vector Field Experienced by a Moving Point

To justify the right hand side of Eq.(5.1) for the total time

derivative of the magnetic vector potential field A as experienced by a moving point charge q symmetry arguments are relevant. Since induction is a slowly varying effect, where relativity theory is appropriate, there should be symmetry between moving source charges and moving detector charges to satisfy Newton's third law.

To preserve complete symmetry between source and detector charges it is necessary to add the term

$$q a \Phi / c^2, \tag{5.42}$$

to the right hand member of Eq.(5.1). It also involves induction phenomena. However, the present Chapter is involved with cases where $\Phi = 0$; and where the force produced by static source charges on accelerating detector charges is not considered. The first term of the right hand member of Eq.(5.1) is given by

$$- q \partial A / \partial tc = - q \int d^3r \, ( \partial J' / \partial tc) \big/ |r - r'|. \tag{5.43}$$

This is the force produced by accelerating charges, as given by $- \partial J' / \partial t$, on the static detector charge q. To preserve symmetry and Newton's third law there should be a force on an accelerating detector charge due to static source charges. The missing term (5.42), being such a force, yields the required symmetry when added to Eq.(5.1).

This important force term, Eq.(5.42) (that is not considered in the present Chapter) is responsible for Lenz' law for the back emf, which is necessary to obey Newton's third law. This term is also involved in self inductance. This force, Eq.(5.42), that is proportional to the absolute acceleration a of the charge q, is also the "inertial" force associated with the mass equivalent of the potential energy, $m = - q \Phi / c^2$. The ability to associate an inertial mass with the self inductance in circuit theory is a consequence of this force. This "inertial" force is also responsible for the Mikhailov experimental results (Secion 4.8). This term (5.42) appears in the Wesley field theory, Eq.(4.48). (This all important force is entirely missing in the insufficient Maxwell-Lorentz electromagnetic theory.)

The second term of the right hand member of Eq.(5.1), given by

$$- q(v \cdot \nabla)A/c = - (q/c)\left[e_x(v \cdot \nabla)A_x + e_y(v \cdot \nabla)A_y + e_z(v \cdot \nabla)A_z\right], \tag{5.44}$$



is the apparent time changing A field experienced by the point charge q moving with the velocity v through the space changing A field. This is the usual time variation as experienced by a point moving through a space changing scalar field; thus the total time change for a point moving through a scalar field f is given by

$$df/dt = \partial f / \partial t + v \cdot \nabla f, \tag{5.45}$$

where v is the velocity of the point. This force, Eq.(5.44), is between the detector charge moving with the velocity v through a field due to source charges moving with the velocities v', as indicated by J'. This force (5.44) is not symmetric between source and detector charges, between A and v. To establish the necessary symmetry a term must be added that interchanges v and A; thus, a force term given by

$$- q(A \cdot \nabla)v. \tag{5.46}$$

This term is already given as the third term of the right hand member of Eq.(5.1). This term cannot arise in a scalar field. This term represents the apparent time rate of change of direction of the vector A field due to the charge changing its direction.

Textbooks present a truncated version of the total time derivative for a point moving through a vector field given by

$$dA/dt = \partial A / \partial t + (v \cdot \nabla)A, \tag{5.47}$$

which is wrong; as the third term on the right of Eq.(5.1) is missing. This textbook error is a *mathematical* error, that arises from the fact that the unit vectors $e_x$, $e_y$, $e_z$ are assumed to remain fixed in direction as experienced by (or as "seen by") the moving point. But when the velocity v vector changes direction the unit vectors, $e_x$, $e_y$, and $e_z$, fixed in absolute space, or the laboratory frame, must appear to rotate. In particular, the following theorem (Wesley 1999c) may be stated and proved:

For any well behaved vector field A the time rate of change as seen (or experienced) by a point moving with the velocity v is given by

$$dA/dt = \partial A / \partial t + (v \cdot \nabla)A + (A \cdot \nabla)v. \tag{5.48}$$

Proof: The total time derivative of A(t,r) is given by

$$dA/dt = d\left[A_i(t,r)e_i\right]/dt, \tag{5.49}$$

where i = 1, 2, and 3, indicating the three cartesian coordinate directions x, y, and z, and $e_i$ is a unit vector, and repeated indicies are summed. Performing the differentiation yields

$$\begin{aligned} dA/dt &= \left[\partial A_i(t,r)/\partial t\right]e_i + \left[(v\cdot\nabla)A_i(t,r)\right]e_i - A_i de_i/dt \\ &= \partial A/\partial t + (v\cdot\nabla)A + A_i de_i/dt, \end{aligned} \tag{5.50}$$

where $x_1 = x$, $x_2 = y$, and $x_3 = z$. It now remains to prove that

$$A_i de_i/dt = (A\cdot\nabla)v. \tag{5.51}$$

Instantaneously a point may be taken as moving on a circle of fixed radius r at a constant tangential speed v to represent the instantaneous *transverse* change in *direction*, or acceleration $a_t$ as $v^2/r$. Introducing polar coordinates centered at the center of the instantaneous circle, the unit vectors $e_x$ and $e_y$ fixed in the laboratory frame or in absolute space become

$$e_x = \cos\phi\, e_r - \sin\phi\, e_\phi, \qquad e_y = \sin\phi\, e_r + \cos\phi\, e_\phi. \tag{5.52}$$

From the point of view of the moving point $e_r$ and $e_\phi$ appear fixed; and the angle $\phi$ appears to be changing in the negative sense; so the apparent time rate of change of the unit vectors $e_x$ and $e_y$ then become

$$\begin{aligned} de_x/dt &= -\dot\phi(-\sin\phi\, e_r - \cos\phi\, e_\phi) = \dot\phi e_y, \\ de_y/dt &= -\dot\phi(\cos\phi\, e_r - \sin\phi\, e_\phi) = -\dot\phi e \end{aligned} \tag{5.53}$$

where $\dot\phi = d\phi/dt$. Substituting this result (5.53) into the left side of Eq.(5.51) yields

$$A_i de_i/dt = \dot\phi(-A_y e_x + A_x e_y) = \dot\phi A_\phi e_\phi. \tag{5.54}$$

The velocity v of the point on the instantaneous circle is given by

$$v = \dot\phi r e_\phi = \dot\phi(-ye_x + xe_y). \tag{5.55}$$

Substituting this result (5.55) into the right side of Eq.(5.51) yields

$$\begin{aligned} (A_x\,\partial/\partial x + A_y\,\partial/\partial y)(-ye_x + xe_y) &= \dot\phi(-A_y e_x + A_x e_y) \\ &= \dot\phi A_\phi e_\phi. \end{aligned} \tag{5.56}$$

Since Eqs.(5.54) and (5.56) yield identical results; Eq.(5.51) has been proved. Q.E.D.



To appreciate the significance of this theorem, Eq.(5.48), the following may be noted:

1) When A is a function of the time only and not of position r, and v is zero or a constant, then

$$dA/dt = \partial A/\partial t, \tag{5.57}$$

which is the case needed for transformer induction.

2) When A is a function of position r but not the time, then

$$dA/dt = (v\cdot\nabla)A + (A\cdot\nabla)v, \tag{5.58}$$

which is the case needed for motional induction.

3) When A is neither a function of time nor position and is thus a constant uniform vector field, then

$$dA/dt = (A\cdot\nabla)v, \tag{5.59}$$

which is a case of motional induction for v a function of position. If v is a constant, then this force of motional induction is zero. This case 3) cannot occur in a scalar field, that has itself no direction. This case 3) must be taken into account for unipolar induction (Section 5.13) in order to yield the net induction observed. This case 3) is overlooked in textbooks and by traditional orthodox physics.

## 5.9 The Aharonov-Bohm Effect

The Aharonov-Bohm (1959) effect involves a beam of coherent electrons that is split into two beams by a thin current carrying solenoid. After travelling on either side of the solenoid, the two coherent beams are combined to form an interference pattern. This interference pattern is observed to shift as a function of the current in the solenoid. There is, thus, a relative phase difference between the two electron waves travelling on either side of the solenoid that depends upon the current in the solenoid.

5.9a The Aharonov-Bohm effect is due to motional induction - The Aharonov-Bohm effect is trivially explained as a motional induction effect (Wesley 1996g, 1998b), where the force of induction, Eq.(5.1) is given for the case where there is a steady current in the

solenoid; so $\partial A/\partial t = 0$. It is sufficient to assume that the electrons travel in straight lines; so $(A\cdot\nabla)v = 0$. Thus, the force of motional induction of interest is given, e replacing q, simply by

$$F = -\,edA/dtc = -\,e(v\cdot\nabla)A. \tag{5.60}$$

Integrating Newton's second law, $dp/dt = -\,edA/dtc$, Eq.(5.60) yields

$$p = p_o - eA/c, \tag{5.61}$$

where $p_o$ is a constant of integration.

The magnetic vector potential A for a long thin solenoid is given by Eq.(5.15),

$$A = \Phi e_\phi/2\pi r = \Phi(-ye_x + xe_y)/2\pi r\ , \tag{5.62}$$

where $e_\phi$, $e_x$, and $e_y$ are unit vectors in the $\phi$, x, and y directions, $r^2 = x^2 + y^2$, and $\Phi = 4\pi^2\eta a^2/c$ is the magnetic B flux in the solenoid of radius $a$ and a current $\eta$ per unit length. An electron may be taken to travel in a straight line in the positive x direction a distance y = b above the solenoid (or a distance y = − b below the solenoid) from $-\infty$ to $+\infty$, as indicated in Fig. 5.7.

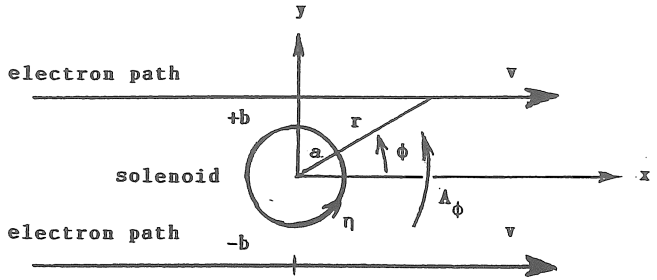



Fig. 5.7 Electron paths for the Aharonov–Bohm effect.

The appropriate plane electron wave is correctly empirically specified by the Wesley wave (Wesley 1965, 1983d, 1991q, 1996h),

$$\Psi = \sin\left[p\cdot(r - vt)/\hbar\right], \tag{5.63}$$

which yields the observed de Broglie wavelength, $\lambda = h/|p|$, the observed wave velocity equal to the particle velocity v, and the observed Planck frequency for photons $\nu = p\cdot v/h = E/h$. (The de Broglie wave is empirically impossible for particles with a nonzero rest mass (Wesley 1983e).)



Since the path lengths for the two interfering electron beams passing above and below the solenoid are precisely the same; the phase difference must arise from the difference in the time of arrival of the electrons. In particular, the phase of an arriving electron, from Eq.(5.61) and (5.62), is given by

$$\Theta = -\int(p\cdot v/\hbar)dt = -\int_{-\infty}^{+\infty}(p_x/\hbar)dx, \tag{5.64}$$

where from Eqs.(5.61) and (5.62) and the path above the solenoid

$$p_x = p_{ox} - Kb/(x^2 + b^2), \tag{5.65}$$

where

$$K = 2\pi e\eta a^2/c^2\hbar = e\Phi/2\pi c\hbar. \tag{5.66}$$

For the path below the solenoid b may be replaced by − b in Eq.(5.65). The desired phase *difference* then becomes

$$\begin{aligned}\Delta\Theta = (-1/\hbar)\int_{-\infty}^{+\infty}\left[p_x(\text{below}) - p_x(\text{above})\right]dx \\ = 2Kb\int_{-\infty}^{+\infty}dx/(x^2 + b^2).\end{aligned} \tag{5.67}$$

Performing the integration, Eq.(5.67) yields

$$\Delta\Theta = 2K\tan^{-1}(x/b)\Big|_{-\infty}^{+\infty} = 2\pi K, \tag{5.68}$$

where the constant K is given by Eq.(5.66). This phase difference (5.68) as a function of $\eta$, the current per unit length in the solenoid, is observed in the laboratory (Peshkin and Tonomura 1989).

Since the path lengths are the same for the two interfering electron beams; and the momenta and energies of the electrons are the same when observed at $+\infty$, as when introduced at $-\infty$; it is not immediately obvious why a phase difference should occur. Some insight into the phenomenon can be gained by examining the pseudo-potential U defined by

$$E = p_x/2m = p_{ox}/2m + U,$$

where E is the total energy and $p_x$ is given as a function of x by Eq.(5.65). Neglecting the small term varying as $v^2/c^2$ in comparison to unity,

$$U = -\,Kp_{ox}b/m\hbar(x^2 + b^2). \tag{5.69}$$

This pseudo-potential is zero for $x = \pm\infty$ It represents a potential valley for electrons passing above the solenoid, opposite to the

direction of the current, and a potential hill (where b is replaced by - b) for electrons passing under the solenoid in the direction of the current. Thus, electrons passing above the solenoid, travelling down and up a potential valley, arrive sooner with a larger net phase; while electrons passing below the solenoid, travelling up and down a potential hill arrive later with a smaller net phase. The A field produced by the solenoid merely changes the phase *constant* of the arriving waves without otherwise altering their physical properties.

5.9 b Orthodox physics and the Aharonov-Bohm effect - Since the only electrodynamic force admitted by *orthodox* physics is the Lorentz force; and the Lorentz force on the electrons outside the solenoid is zero; no Aharonov-Bohm effect is supposed to occur. In particular, the magnetic B field, $\mathbf{B} = \nabla \times \mathbf{A} = 0$ outside the long thin solenoid, where A is given by Eq.(5.62); so the Lorentz force $\mathbf{v} \times \mathbf{B} = 0$. In an attempt to explain the actual occurrence of an Aharonov-Bohm effect Bohm (1993) claims that it is a strange mysterious quantum mechanical effect and not an electrodynamic effect apart from quantum mechanics.

As demonstrated above, the contrary is true: The electrodynamic force of motional induction, Eq.(5.60), accounts for the Aharonaov-Bohm effect, quite independent of any quantum phenomena. The relative phase difference between the two coherent electron beams is merely a particular way to detect the force of motional induction. The force of motional induction, Eq.(5.60), may also be detected by examining the trajectory of a single electron beam passing near the solenoid without any interference, or quantum phenomenon being involved. The Aharonov-Bohm effect has, thus, nothing at all to do, per se, with the quantum, or wave, behavior of electrons.

The existence of the Aharonov-Bohm effect may be taken as empirical evidence (in addition to the evidence presented below) for the existence of the motional induction force given by Eq.(5.60) and for the failure of orthodox physics with its Lorentz force.

Orthodox theory fails; because it is based upon the false idea that the magnetic B field is fundamental. The magnetic vector potential A is supposed to be defined as merely an *arbitrary* mathematical generating function for the B field, such that $\mathbf{B} = \nabla \times \mathbf{A}$. According to the orthodox Maxwell equations, that are



invariant to the choice of arbitrary "gauges" and are thus ambiguous and not unique, the A field is supposed to be arbitrary to within the gradient of *any* scalar function! The A field is not supposed to be able to account directly for any force at all, such as the force of motional induction, Eq.(5.60). However, to be empirically correct, the magnetic vector potential A field must be regarded as physically real and *fundamental*; because it is *defined* directly and *uniquely* in terms of the source currents,

$$\mathbf{A} \equiv \int d^3r' \mathbf{J}'/Rc. \tag{5.70}$$

It is defined directly in terms of the *causes* of electrodynamic phenomena. The B field is merely a secondary aspect or *effect* produced by the A field, that is defined by $\mathbf{B} \equiv \nabla \times \mathbf{A}$.

The A field is employed in the orthodox "Lagrangian formalism" chosen to yield the Lorentz force (Goldstein 1950). Using "Lorentz covariant formalism", the orthodox Hamilton for an electron in a potential A field is supposed to be

$$H = (p - eA/c)^2/2m. \tag{5.71}$$

There is no valid theoretical nor experimental evidence that this particular "Hamiltonian" equals the energy of an electron in an A field. The "Lagrangian method", being merely a tautological representation of what is known already (if done correctly) is of no value; and the "Lorentz covariant formalism" of "special relativity" has no physical justification (Galeczki and Marquardt 1997).

Bohm (Aharonov and Bohm 1959) substituted this contrived "Hamiltonian", Eq.(5.71) into Schroedinger's time dependent equation, making the operator replacement $p \rightarrow -i\hbar\nabla$, to obtain

$$-i\hbar\,\partial\Psi/\partial t = (-i\hbar\nabla - eA/c)^2\Psi/2m. \tag{5.72}$$

This Bohm result (5.72) makes no sense; because the Schroedinger time dependent equation with its irreplaceable $i = \sqrt{-1}$ can represent nothing physically real (the all important phase being totally ambiguous); and the "operator approach" is not admissible (as shown by Wesley 1983f, 1983g, and 1983h).

Bohm noted that the vector potential A, Eq.(5.62), can be mathematically represented as the gradient of a scalar, $\mathbf{A} = \nabla\zeta$, where $\zeta = (\Phi/2\pi)\,ln\,r$. Integrating A around a closed path that

includes the origin then yields

$$\oint \mathbf{A}\cdot d\mathbf{s} = (\Phi/2\pi)\int_0^{2\pi} (1/r)\, r\, d\phi = \Phi. \qquad (5.73)$$

He found a solution to the wave Eq.(5.72) of the form

$$\Psi = \psi' \exp(ie\zeta/c\hbar), \qquad (5.74)$$

where $\psi'$ is a solution to the free space wave equation

$$-i\hbar\, \partial\psi'/\partial t = -\hbar^2 \nabla^2 \psi'. \qquad (5.75)$$

He concluded that the phase difference between any two paths, above and below, the solenoid would equal

$$\Delta\Theta = e\Phi/c\hbar, \qquad (5.76)$$

in agreement with observations.

It is astonishing that Bohm was able to guess at a result in agreement with observations, considering all of the erroneous formal orthodox arguments he used. He did not, however, understand the physics; as he believed the effect had to be a quantum mechanical effect, rather than simply an electrodynamic effect.

## 5.10 The Marinov Motor

The "Marinov motor" was apparently first investigated by Marinov (1997) as his "siberian coliu machine". The correct theory for its operation was first given by Wesley (1998c, 1998d). Working models of the Marinov motor have been constructed by a number of individuals besides Marinov (eg., Kooistra 1997, Monstein 1998, and Phipps 1998a and 1998b).

(Ironically, I wrote the correct theory for the Marinov motor without knowing that Marinov had already committed suicide five weeks earlier. Marinov's life was full of frustrations. For example, he never received due recognition for his most brilliant "coupled mirrors experiment" measuring the absolute velocity of the closed laboratory. In his *last* letter to Pappas, four days before his suicide, he complained of a *final* frustration: After three years of intense effort, he still was unable to discover the explanation for why his motor functioned.)

The essential features of the Marinov motor are indicated in Fig. 5.8. The annular rotor is a copper ring fed current through



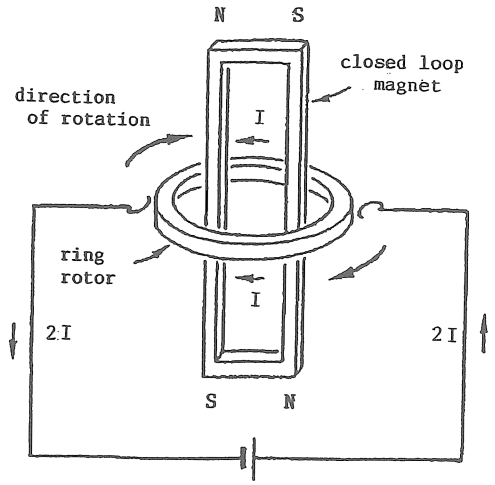



Fig. 5.8 The essential elements of the Marinov motor (from *Physics as a Science*, Hadronic Press, 1998).

brushes. The ring rotor passes around a closed loop magnet. Direct current is fed into the ring rotor at the two opposite points nearest to the magnet, as shown. When current flows the rotor rotates.

It needs to be mentioned here that Fig. 5.8 is an "exploded diagram" to indicated the elements involved and to illustrate the approximate theory presented below. This Fig. 5.8 is not suitable to construct an actual working model. The torques that can be achieved are not large; so care must be taken to optimize the differential A field that drives the rotor. Marinov, for example, cut a cylindical magnet in half lengthwise, and joined the two halves together with reversed polarities to fill the entire space within the ring rotor.

According to orthodox physics the Marinov motor should not function; since the only admissible force, the Lorentz force, is zero on any moving charge outside of the closed loop magnet. In particular, there is no electrostatic field, so $-\nabla\Phi = 0$; there is no time changing source current, so $\partial \mathbf{A}/\partial t = 0$; and all of the

magnetic B lines are contained within the closed loop magnet and none outside, so $\mathbf{v}\times\mathbf{B} = 0$; thus,

$$\mathbf{F}(\text{Lorentz})/q = -\nabla\Phi - \partial\mathbf{A}/\partial tc + \mathbf{v}\times\mathbf{B}/c = 0. \tag{5.77}$$

Yet the motor functions. (A number of defenders of the orthodox theory have constructed obviously insufficient devices, that cannot work, in order to claim that the Marinov motor does not work!)

The force, driving the Marinov motor, is the force of motional induction, given by Eq.(5.60) (the force that is also responsible for the Aharonov-Bohm effect, discussed in the previous Section 5.10). In particular, the velocity $\mathbf{v}$ is the velocity of the current carrying electrons in the ring rotor; so $q\mathbf{v}$ is to be replaced by $Id\mathbf{s} = Ir\,d\phi\,\mathbf{e}_\phi$. For the present approximate theory the closed loop magnet may be replaced by two thin infinitely long magnets at $y = \pm b$ of opposite polarity, as indicated in Fig. 5.9. In this case the magnetic vector potential A is given by Eq.(5.62). The A field for the two magnets is obtained by adding the individual fields to yield

$$\begin{aligned} A_r &= 2Kb(r^2 + b^2)\cos\phi/Q^4, \\ A_\phi &= 2Kb(r^2 - b^2)\sin\phi/Q^4, \end{aligned} \tag{5.78}$$

where the cylindrical coordinates r and $\phi$ are taken with respect to the center of the ring rotor of fixed radius r, as indicated in Fig. 5.9, and where

$$K = \Phi/2\pi c, \tag{5.79}$$

where $\Phi$ is the magnetic B flux in the magnet (where $\Phi = 4\pi^2\eta a^2/c$ for an equivalent solenoid of radius $a$, carrying a current $\eta$ per unit length), and where

$$Q^4 = (r^2 + b^2)^2 - 4b^2r^2\sin^2\phi\,. \tag{5.80}$$

From Eq.(5.60) the tangential force on an element of the ring is given by

$$dF_\phi = -I\left[(d\mathbf{s}\cdot\nabla)\mathbf{A}\right]_\phi, \tag{5.81}$$

where operating on a function of $\phi$ alone,

$$d\mathbf{s}\cdot\nabla = d\phi\,(\partial/\partial\phi). \tag{5.82}$$

Thus,

$$dF_\phi = Id\phi\left[\mathbf{e}_x\partial A_x/\partial\phi + \mathbf{e}_y\partial A_y/\partial\phi\right]_\phi = Id\phi\mathbf{e}_\phi\left[-\sin\phi\,\partial A_x/\partial\phi + \cos\phi\,\partial A_y/\partial\phi\right]. \tag{5.83}$$



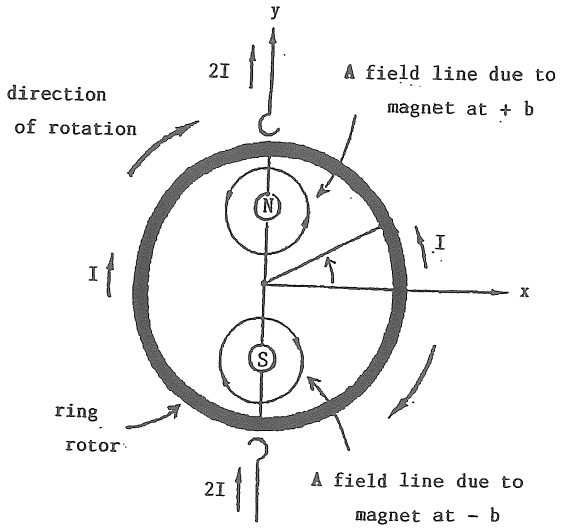



Fig. 5.9 Choice of coordinates, location of the infinitely long thin magnets at $y = \pm b$, the direction of the current flow in the rotor, and the direction of the rotation produced.

Substituting

$$A_x = \cos\phi\,A_r - \sin\phi\,A_\phi, \qquad A_y = \sin\phi\,A_r + \cos\phi\,A_\phi, \tag{5.84}$$

into Eq.(5.83) then yields the desired result

$$dF_\phi = -Id\phi\,(\partial A_\phi/\partial\phi + A_r). \tag{5.85}$$

Noting the direction of current flow, positive in the first quadrant, negative in the second and third quadrants, and positive in the fourth quadrant, each quadrant delivers the same tangential force on the ring. Integrating Eq.(5.85) using Eqs.(5.78) and (5.80) then yields the net torque on the ring,

$$T = rF_\phi = -4IK\left\{2br/(r^2 - b^2) + ln\left[(r + b)/(r - b)\right]\right\}. \tag{5.86}$$

If the current is fed in at $\phi = 0$ and out at $\phi = \pi$ (or equivalently, the closed loop magnet is rotated through 90°), then the net torque on the ring rotor will be zero. Rotating the closed loop magnet through 180° will cause the rotor to rotate in the opposite

sense. According to the insufficient Maxwell theory, the magnetic B field, being zero outside the closed loop magnet, it is supposed to be impossible to know the direction of the B field inside of the closed loop magnet. Here the direction of rotation of the ring rotor in the Marinov motor yields the direction of the B filed inside of the closed loop magnet.

Instead of the copper ring rotor, an annular trough of circulating mercury can be used. In this case, the contact brushes are replaced by wire ends immersed in the mercury. Another variation (Kooistra 1997) involves a fixed ring with a suspended rotating closed loop magnet.

The Marinov motor functions as a generator when the rotor (or the mercury) is driven by an outside power source (Marinov 1997, Monstein 1998).

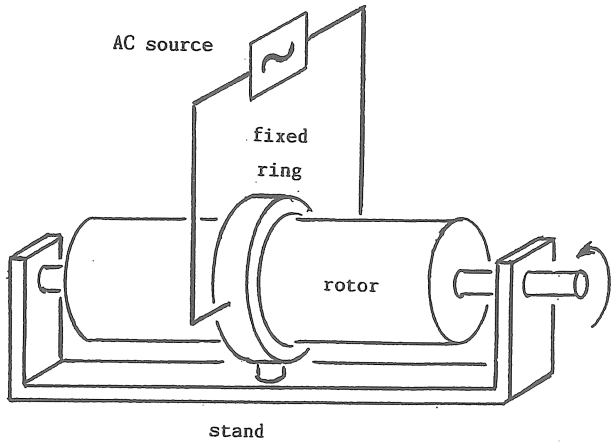
### 5.11 A Variation of the Marinov Motor Requiring No Brush contacts

Since the principles of how the Marinov motor functions are clear; variations may be readily envisioned. To avoid brushes or mechanical contacts a brushless motor may be constructed as indicated in Fig. 5.10. The rotor is a closed loop magnet constructed from a cylindrical magnet cut lengthwise with the two halves joined together with opposite polarity, as shown. Soft iron circular yokes are cemented to each end. The copper ring may be held fixed with permanet current leads fed by an oscillating current source.

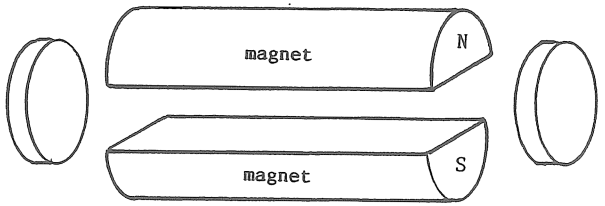
Once the rotor has rotated more than 90° from the position of maximum torque; the current direction is altered; so the torque on the rotor remains in the same direction. The rotor will then continue to rotate at half of the applied current frequency. Like the usual "squirrel cage induction motor", no contacts or brushes are required.

To avoid a possible "dead point", where the torque is zero, one or more additional copper rings can be placed around the rotor with the current fed into the rings at different positions of the current leads.






brushless Marinov motor




exploded view of rotor

Fir. 5.10 Diagram of the essential elements for a proposed brushless Marinov motor.

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### 5.12 Unipolar Induction

Unipolar induction involves the generation of an emf (electromotive force), or a potential difference, that can deliver energy when a current is allowed to flow. A potential difference is created between the center and the rim of a rotating disc (or rotating wire) placed above the pole face of a magnet, as indicated in Fig. 5.11. This effect was first discovered by Faraday (1832, 1852). Although the effect has been demonstrated countless times since then; it continues to produce theoretical headaches. In particular, when the

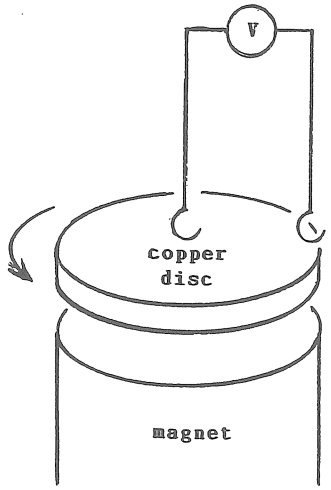


Fig. 5.11 The essential elements involved in unipolar induction.

magnet is rotated with the disc stationary, no emf is induced. If the magnet is stationary, or if it rotates with the disc, the same emf is induced. And, when the entire circuit, disc plus voltmeter is rotated as a unit above the magnet (assuming the A field, and thus the B field remains essentially the same throughout the circuit) no emf is induced.

Two questions are involved: 1) What is the cause of the emf? 2) And what is the explanation for the peculiar behavior of the relative rotation of magnet and disc that produces, or does not produce, an emf?

5.12a The cause of unipolar induction - Faraday presented the idea that a conductor "cutting lines of force" (i.e., magnetic B lines) produces the observed induction. This is still the most popular explanation, even today. Unfortunately, when the magnet is co-rotated with the disc, the conductor (the disc) cannot cut any lines of force, if these lines rotate with the magnet; yet an emf is produced. It is usually claimed that the magnetic B lines do not rotate with the magnet, which gives the B lines a mysterious



nonphysical property. Some claim that the observed emf is produced in this case by the remainder of the circuit, apart from the disc, cutting the lines of force that, being fixed to the magnet, rotate with the magnet. But this possible explanation is ruled out by Müller's brilliant, but elementary method (discussed below), proving that the seat of the emf remains in the disc, when the disc and magnet are corotated together. The "cutting lines of force" idea cannot give a satisfactory explanation for unipolar induction.

Some proponents of the deficient Maxwell theory would like to see unipolar induction explained by the "flux rule". Somehow the magnetic flux through the circuit, including the disc and voltmeter, is supposed to experience a change with time due to the rotation. Since only a steady rotation is involved; nothing whatsoever can change with time. And the magnetic B field, being perpendicular to the face of the magnet, lies in the plane of the circuit containing the voltmeter; so the magnetic flux through the circuit remains precisely zero and does not change with time. The "flux rule" cannot be used to explain unipolar induction.

The primary difficulty with these attempted orthodox explanations lies in the unfortunate use of the magnetic B field. In general the use of the B field can lead to difficulties; it is best avoided entirely. The basic physical cause can only be provided by the magnetic vector potential A field, that is defined directly in terms of the source current. In particular, unipolar induction is explained unequivocally by the force of induction given by Eq.(5.1).

The A field above the face of the magnet may be taken to a sufficient accuracy here as

$$A = B_z r e_\phi/2 = B_z(-ye_x + xe_y)/2, \tag{5.87}$$

where $B_z$ is the magnetic field produced by the magnet, that can be taken as a constant to a sufficient accuracy here. The velocity v is the velocity of the conduction electrons in the copper disc by virtue of the rotation of the disc; thus,

$$v = \omega r e_\phi = \omega(-ye_x + xe_y), \tag{5.88}$$

where $\omega = \dot{\phi}$ is the constant angular velocity of rotation. The

positive lattice ions and bound electrons, that are not free to move, have precisely the same velocity $\mathbf{v}$ due to rotation; but, because they are not free to move relative to the disc, they cannot contribute to the induced emf.

Since the A field is not changing with time; the appropriate force of induction for unipolar induction is given from Eq.(5.1) by

$$\mathbf{F} = -q(\mathbf{v}\cdot\nabla)\mathbf{A}/c - q(\mathbf{A}\cdot\nabla)\mathbf{v}/c. \tag{5.89}$$

The operator $(\mathbf{v}\cdot\nabla)$ from Eq.(5.88) is given by

$$\mathbf{v}\cdot\nabla = (-y\,\partial/\partial x + x\,\partial/\partial y). \tag{5.90}$$

Operating with this operator on A as given by Eq.(5.87), the first term on the right of Eq.(5.89) is

$$-q(\mathbf{v}\cdot\nabla)\mathbf{A}/c = qK\omega r/c = qB_z\omega re_r/2c. \tag{5.91}$$

Similarly from Eqs.(5.87) and (5.89) the second term on the right of Eq.(5.89) is

$$-q(\mathbf{A}\cdot\nabla)\mathbf{v}/c = qB_z\omega re_r/2c. \tag{5.92}$$

Combining Eqs.(5.91) and (5.92) the force of induction on a carrier electron of charge q becomes

$$\mathbf{F} = qB_z\omega re_r/c = q\mathbf{v}\times\mathbf{B}/c, \tag{5.93}$$

where the expression on the right is formally equal to the Lorentz force, where from Eq.(5.87)

$$\mathbf{B} = \nabla\times\mathbf{A} = B_z\mathbf{e}_z. \tag{5.94}$$

Using vector identities the force for unipolar induction, Eq.(5.89), may also be written as

$$\mathbf{F} = q\mathbf{v}\times(\nabla\times\mathbf{A})/c + q\mathbf{A}\times(\nabla\times\mathbf{v})/c - q\nabla(\mathbf{v}\cdot\mathbf{A})/c, \tag{5.95}$$

where the first term on the right equals the Lorentz force. From Eqs.(5.88) and (5.94) the first term on the right of Eq.(5.95) is

$$q\mathbf{v}\times(\nabla\times\mathbf{A})/c = qB_zve_r/c, \tag{5.96}$$

as already given by Eq.(5.93). The curl of v from Eq.(5.88) becomes

$$\nabla\times\mathbf{v} = \omega\,\mathbf{e}_z; \tag{5.97}$$

so from Eqs.(5.87) for A the second term on the right of Eq.(5.95) becomes



$$q\mathbf{A}\times(\nabla\times\mathbf{v})/c = qB_zve_r/c, \tag{5.98}$$

the same as the first term on the right of Eq.(5.95). The scalar product of v and A from Eqs.(5.87) and (5.88) is given by

$$\mathbf{v}\cdot\mathbf{A} = \omega B_z r^2/2; \tag{5.99}$$

so the third term on the right of Eq.(5.95) is

$$-q\nabla(\mathbf{v}\cdot\mathbf{A})/c = -qB_zve_r/c. \tag{5.100}$$

Combining Eqs.(5.96), (5.98), and (5.100) again yields Eq.(5.93), as it should.

It is now clear that the Lorentz force, being only a portion of the actual force of induction, Eq.(5.95), is merely accidentally in agreement with the correct force, given by Eq.(5.93).

The emf induced in the disc may be obtained by integrating the force per unit charge from the center of the disc to the rim, where $r = a$; thus,

$$\text{emf} = \int(\mathbf{F}/q)\cdot d\mathbf{s} = (\omega B_z/c)\int_0^a r\,dr = \omega B_z a^2/2c, \tag{5.101}$$

which is the voltage difference that should be registered by the voltmeter indicated in Fig. 5.11.

5.12b Müller's method for unipolar induction for the seat of emf — The Müller method to distinguish between two possible seats of an emf has been already discussed in Section 5.5 above. This method is of particular interest for unipolar induction, where it has been argued for more than 150 years as to whether the seat of the observed emf, when both magnet and disc are rotated together in unison, is in the disc or is in the remaining portion of the circuit.

Müller's setup to determine the seat of emf for unipolar induction is indicated in Fig. 5.12. The occurrence of a transient voltage $V_1$ indicates an emf induced in the wire pq. The occurrence of a transient voltage $V_2$ indicates an emf induced in the wire sr. With this setup the three elements involved, the magnet, the wire pq (serving as the disc), and the wire sr (serving as the remainder of the circuit) can be each moved independently, or in unison with one or both of the other two elements. A variation, not shown in Fig. 5.12, involves a soft iron yoke between the magnet and the

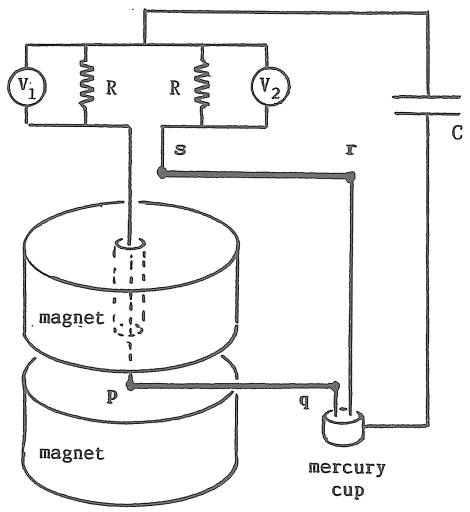


Fig. 5.12 Francisco Müller's setup to localize the seat of unipolar induction.

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wire sr that shields the wire from any magnetic B field.

Müller's results for all possibilities are summarized in Table 5.1. Studying all of the possibilities presented in the Table, it is clear that the "cutting lines of force" idea of Faraday cannot be valid. Moreover, the Maxwell flux rule cannot explain the results; because, apart from the fact that no magnetic B flux can be defined, the emf is localized and is not distributed around the whole current loop, as would be apparently required, if the flux rule were correct and if the emf were dependent upon the magnetic B field *throughout* the enclosed loop.

5.12c The reason why the rotation of the magnet produces no effect - It may be seen from Table 5.1 that the emf induced is quite independent of whether or not the magnet is rotated with respect to the wire in which the emf is induced. This seemingly peculiar fact would make it appear that the *relative* movement of the wire and the magnet is not necessary. It is, thus, frequently claimed that this is an example of the existence of a phenomenon involving



Table 5.1 Seat of unipolar induced emf for different cases

| case | oscillating magnet | oscillating wire pq | oscillating wire rs | no yoke emf pq | no yoke emf rs | with yoke emf pq | with yoke emf rs |
|---|---|---|---|---|---|---|---|
| 1 | – | – | – | 0 | 0 | 0 | 0 |
| 2 | – | – | ω | 0 | + | 0 | 0 |
| 3 | – | ω | – | + | 0 | + | 0 |
| 4 | ω | – | – | 0 | 0 | 0 | 0 |
| 5 | – | ω | ω | cancelled | | + | 0 |
| 6 | ω | – | ω | 0 | + | 0 | 0 |
| 7 | ω | ω | – | + | 0 | + | 0 |
| 8 | ω | ω | ω | cancelled | | + | 0 |

the *absolute* velocity of the moving wire alone, a phenomenon that would, thus, seem to demonstrate the existence of *absolute space*. But this is not true! There *must* be relative motion between the source of the A field and the moving detecting charge q in order for motional induction to occur.

Absolute motion can be detected in the closed laboratory. Marinov, using the anisotropy of the oneway velocity of light, measured the absolute velocity of the closed laboratory (as discussed in Sections 1.7f & g). The absolute velocity of the closed laboratory can be obtained from the gamma factor, $\gamma = 1/\sqrt{1 - v^2/c^2}$, where the velocity v is the absolute velocity, as achieved by Monstein and Wesley (as discussed in Section 1.11). As made clear in Chapter 1, absolute space exists; and the physics in the local laboratory can involve absolute velocities. But induction is not one of the phenomena that requires absolute velocities. Only *relative* velocities are required for slowly varying local effects, which includes induction.

The *illusion*, or the false impression of *absolute* motion, arises from two *relativity* effects that annul each other. In particular, a wire carrying a current I is observed to carry precisely the same current I, no matter what the velocity of the wire might be parallel to the wire. Thus, it might be falsely assumed that the phenomenon of a current in a wire represents an *absolute* velocity flow of the carrier electrons; and the velocity of the wire itself is not involved. The phenomenon of current flow in a wire is a matter of of the carrier electrons flowing *relative* to the positive lattice ions. If the carrier electrons have a velocity v relative to the

lattice ions, then, when the wire is moved with the velocity v' parallel to v, the carrier electrons have a velocity v + v'. The electron current is, thus, increased from - I to - I - ρAv', where ρ is the density of carrier electrons and A is the cross sectional area of the wire. But, since the net charge in the wire is neutral; the moving wire also produces a current due to the moving positive lattice ions equal to + ρ Av'. The net electron current observed in the laboratory, thus, remains simply - I, quite independent of the velocity of the wire v'. At the same time the electron current flow *relative* to the positive lattice ions does not change; and the phenomenon remains a *relativity* phenomenon. Thus, two *relativity* effects, one involving the carrier electrons and the other involving the positive lattice ions annul each other, giving the illusion of an *absolute* effect.

From this discussion it is clear that a cylindrical solenoid, rotating about its axis of symmetry, will have always the same current I with respect to the laboratory quite independent of its rate of rotation. The circular wires of the solenoid move parallel to themselves; so the current they carry remains independent of their velocity of rotation. The magnetic vector potential A field produced by such a rotating cylindrical solenoid will, thus, remain precisely the same, quite independent of the rate of rotation of the solenoid.

Since permanent cylindrical magnets behave precisely the same as current carrying solenoids; such a permanent magnet when rotated about its axis of symmetry (parallel to its internal B field) will produce the same magnetic potential A field, and thus B field, quite independent of its rate of rotation. The apparent independence of the *relative* motion of the magnet in unipolar induction is, thereby, explained as a *pseudo-effect* an *illusion*. The phenomenon of unipolar induction remains a *relativity* effect.

5.12d The ponderomotive force on the disc - in addition to the force on the carrier electrons giving rise to an induced emf, there are also forces on the positive ions. The number of positive ions per unit volume that must be considered may be taken as equal to the number of carrier electrons per unit volume. The ions neutralized by permanently attached electrons cannot function electrically.



In addition to the induced radial force on the carrier electrons producing the emf, the electrons experience an azimuthal force due to their radial current flow velocity,

$$\mathbf{v}(\text{current flow}) = v_o \mathbf{e}_r . \tag{5.102}$$

This radial flow produces an induction force also given by Eqs.(5.89) or (5.95) and (5.87), where in this case the velocity v is given by Eq.(5.102); thus,

$$\mathbf{F}(\text{current flow}) = - qB_z v_o \mathbf{e}_\phi / c . \tag{5.103}$$

From Newton's third law and the Coulomb attraction between every carrier-electron-ion pair all forces experienced by the electrons are also experienced by the positive ions in the opposite direction. Thus, this induction force, Eq.(5.103), for the radial flowing current charge q of velocity $v_o$ gives rise to a force on the ions given by

$$\mathbf{F}(\text{ion}) = + qB_z v_o \mathbf{e}_\phi / c . \tag{5.104}$$

Since the ions are fixed to the disc; this is the ponderomotive force on the disc due to the induced current flow.

The induction force driving the electrons radially to produce the emf is necessarily matched by a radial force on the ions in the opposite direction. Since the positive ions are constrained to have no radial motion; this force produces no effect other than a trivial radial tension in the copper disc. However, the azimuthal force on the ions due to the radial current flow, as given by Eq.(5.104), can result in a rotation of the disc; as the ion's motion in the azimuthal direction is not constrained.

When an outside current source is applied the tangential force, Eq.(5.104) gives rise to a unipolar motor. The net current flow is given by $qv_o = q(dr/dt) = Idr$; so the net torque on the disc of radius *a* is given by

$$T = (I/c)B_z \int_o^a r dr = IB_z a^2/2c . \tag{5.105}$$

The rate that work is done by the disc becomes

$$dW/dt = I\omega B_z a^2/2c . \tag{5.106}$$

The power input, taken as IV, where V is the induced emf, Eq.(5.101),

is given by

$$IV = I\omega B_z a^2/2c, \tag{5.107}$$

which, conserving energy, agrees with Eq.(5.106).

Finally, to mention all of the four possible effects involved, radial and azimuthal forces on the electrons and the radial and azimuthal forces on the ions, the azimuthal forces on the carrier charges, Eq.(5.103), give rise to an azimuthal displacement of the electrons, that results in a permanent (with respect to the laboratory) electrostatic charge separation that produces an electrostatic force on the electrons that exactly counter balances the azimuthal force of induction given by Eq.(5.103).

## 5.13 Induced Electromotive Force Versus Ponderomotive Force

It is often assumed that somehow the presence of an electromotive force (emf) precludes the existence of a ponderomotive force, and vise versa. But this is not true. For example, there is a ponderomotive force on the Faraday disc that must be countered by an applied force in order to produce a simultaneous emf. Whatever forces act on the carrier electrons, precisely the same forces (acting in the opposite direction) must act on the positive ions (that donate the conduction electrons). The electrons and ions are coupled by Coulomb attraction to form a force couple of action and reaction that must satisfy Newton's third law.

Unfortunately, an "electromotive force (emf)" is often assumed to mean a force that induces a *flow* of electrons; and a "ponderomotive force" is assumed to mean a force that induces mass motion. But *forces* need not induce motion. It is primarily the *constraints* that determine whether or not electrons will flow, or ions will move. Most induced forces give rise to only static effects, resulting in no motion at all.



CHAPTER 6

# NEOMECHANICS

Neomechanics has been derived from mass energy equivalence,

$$E = c^2 m, \tag{6.1}$$

in Section 1.10 by associating a mass equivalent to the kinetic energy K of a body equal to $K/c^2$. From Newton's second law, $F = d\left[(m + K/c^2)v\right]/dt$, the kinetic energy of a body of mass m (the rest mass) is then given by

$$K = c^2 m(\gamma - 1) \qquad \text{where} \qquad \gamma = 1/\sqrt{1 - v^2/c^2}; \tag{6.2}$$

and the momentum p is then $(m + K/c^2)v$, or

$$p = m\gamma v. \tag{6.3}$$

It is also possible to associate a mass $m^*$ with the momentum, that varies with the velocity; thus,

$$p = m^* v \qquad \text{where} \qquad m^* = m/\sqrt{1 - v^2/c^2}, \tag{6.4}$$

where m is again the rest mass.

The distinction between neomechanics and classical Newtonian mechanics involves the $\gamma$ factor, Eq.(6.2), which is defined for the absolute velocity of the body. Newtonian mechanics involves *absolute* accelerations, but only *relative* velocities, velocities relative to an "inertial frame" (a frame of reference with a zero *absolute* acceleration). Since any frame of reference moving with a constant uniform velocity defines an "inertial frame"; velocities are not uniquely defined in Newtonian mechanics. However, for one particular problem Newtonian mechanics demands only *one* particular inertial frame. The constants of the motion for Newtonian mechanics are, thus, not unique; they depend upon the particular inertial frame

chosen. In contrast, neomechanics involves no such arbitrary inertial frame, no arbitrary relative velocities, and no arbitrary constants of the motion. Partial or approximate solutions in neomechanics may, of course, yield the solution to a problem in some particular inertial frame. In-other-words, under appropriate circumstances neomechanics reduces to classical Newtonian mechanics.

Considering the success of classical Newtonian mechanics, it is of interest to investigate the consequences of neomechanics as compared with those of Newtonian mechanics. The success of Newtonian mechanics also serves as a guide to find proper solutions to problems in neomechanics. For small velocities, $v^2/c^2 < 1$, the neomechanical solution may reduce to the Newtonian limit for some appropriately chosen inertial frame (or nonaccelerating frame) and appropriately chosen constants of the motion.

The two body problem is investigated in this Chapter to illustrate how problems in neomechanics might be solved in general. A two body neomechanical problem has already been solved in Section 3.13 for the planet Mercury moving under the action of the central gravitational force of the Sun, as prescribed by Wesley gravitation. Considering the approximation, Eq.(3.33), precisely the same result is also obtained assuming Newton's universal law of gravitation. Since the absolute velocity of the solar system is small compared with c (see Table 1.1); and, since the velocity of Mercury relative to the Sun is also small compared with c; only a very slight departure from classical Newtonian theory is obtained, namely a very small additional precession of the perihelion of Mercury.

## 6.1 Neomechanics Is Not "Special Relativity"

Because "special relativity" has become established as a widely accepted *religion* (It is not a *science*!); many ideas have become fixed in the popular mind as truths, that are very much contrary to fact. In the popular mind mass energy equivalence, Eq.(6.1), was *first* discovered by Einstein in 1905 as a consequnce of the hypothetical variable space-time of "special relativity". Actually, the idea dates back to at least Newton. The coefficient remained speculative until the 18 hundreds, when, from electrodynamic



considerations, it was recognized as being of the order of magnitude of $c^2$. Quantitative empirical verification to two places of the magnitude of the coefficient in Eq.(6.1) was not established until the 1930's. Neomechanics is based upon the important principle of mass energy equivalence, Eq.(6.1), as established by serious research in the 18 hundreds and by the much later experimental evidence. Neomechanics is quite independent of the hypothetical variable space-time nonsense of "special relativity".

In the popular mind mass change with velocity, Eq.(6.4), was also *first* discovered by Einstein in 1905 as a consequence of the hypothetical variable space-time claims of "special relativity". Actually, electrodynamic considerations in the 18 hundreds had already established the fact that mass should change with velocity. The experiments of Kaufmann (1901, 1902, 1903), performed prior to 1905, confirmed mass change with velocity as given by Eq.(6.4). Neomechanics, which yields mass change with velocity, Eq.(6.4), as simply a consequence of mass energy equivalence, is thus based upon the serious theoretical and experimental research done prior to the advent of the hypothetical variable space-time nonsense of "special relativity".

The origin of the unfortunate "special relativity" can be traced back to Lorentz' naive misinterpretation of Voigt's (1887) equations giving the Doppler effect for light in *absolute* space and time. Because Voigt represented his Doppler effect in terms of space and time variables, instead of in terms of the propagation constant $\mathbf{k}$ and the frequency $\omega$ (Wesley 1986); Lorentz interpreted Voigt's equations to mean that rods could somehow actually contract in the direction of their motion by the factor $1/\gamma$. Lorentz then usurpted Voigt's equations and presented them as his *own* "Lorentz transformation of space and time". Since Voigt believed in absolute space and time; the "Lorentz transformation" is an outrageous misrepresentation of Voigt's equations.

Neomechanics is based upon unique *absolute* space and time; so the only admissible space-time transformation is the Galilean transformation. The hypothetical variable space-time, as represented by the Lorentz transformation, is not permitted in neomechanics. To

stress the great difference between neomechanics and "special relativity" (SR) the following points may be briefly mentioned:

1) Neomechanics assumes unique absolute space and time - SR assumes a hypothetical variable space-time.
2) Neomechanics depends upon unique absolute velocities - SR depends upon relative, and thus ambiguously defined, velocities.
3) Neomechanics accepts the correct history of mass-energy equivalence - SR falsely claims discovery post facto.
4) Neomechanics accepts the correct history of mass change with velocity - SR falsely claims discovery post facto.
5) Neomechanics is a theory of *mechanics* that goes beyond Newton - SR is a space-time theory involving a hypothetical variable space-time not compatible with Newtonian absolute space-time.
6) Neomechanics has no paradoxes - SR suffers from many inconsistencies, such as twins returning from fast round trips being each younger than the other.
7) Neomechanics involves a unique gamma factor, $\gamma = 1/\sqrt{1 - v^2/c^2}$, where the velocity v is the absolute velocity - SR involves an ambiguous $\gamma$ factor with a relative, and thus ambiguous, velocity v.
8) Neomechanics permits unique solutions to problems - SR can yield only ambiguous results due to ambiguous velocities, arbitrary inertial frames of reference, arbitrary "points of view", etc.

## 6.2 The Classical Newtonian Two Body Problem

In order to consider the neomechanical two body problem it is first necessary to consider the classical Newtonian two body problem, which serves as a limiting case for $v^2/c^2 < 1$.

6.2a Newton's classical second law and integrals of the motion - The two body problem involves finding the motion of two bodies, one of mass m at r and the other of mass m' at r', where mass m' exerts a force **F** on mass m and mass m exerts a force **F'** on m'. The forces **F** and **F'** act along the line joining the two bodies; and their magnitude is a function of the distance between the two bodies, $R = |\mathbf{r} - \mathbf{r}'|$. In order to satisfy Newton's third law,

$$\mathbf{F} = -\mathbf{F}', \tag{6.5}$$



The forces may be written as

$$\mathbf{F} = f(R)\mathbb{R}, \qquad \mathbf{F}' = -f(R)\mathbb{R}, \tag{6.6}$$

where $\mathbb{R} = \mathbf{r} - \mathbf{r}'$. Newton's second law then yields

$$\mathbf{F} = f(R)\mathbb{R} = m\ddot{\mathbf{r}}, \qquad \mathbf{F}' = -f(R)\mathbb{R}' = m'\ddot{\mathbf{r}}', \tag{6.7}$$

where dots above symbols indicate time derivatives, $\dot{\mathbf{r}} = \mathbf{v}$, $\ddot{\mathbf{r}} = \mathbf{a}$, etc.

Newton's second law, Eqs.(6.7), is only valid in an "inertial frame", in a frame of reference that has a *zero absolute acceleration* and thus in a frame that has constant uniform, or zero, *absolute* velocity. Newton's second law is, thus, only valid for *absolute accelerations*. In an accelerating frame of reference, or in a "noninertial frame", the *absolute* acceleration of the frame of reference gives rise to pseudo-forces, such as the Coriolis force due to the centripetal acceleration of the Earth's surface produced by the Earth's rotation.

Adding Eqs.(6.7) yields

$$m\ddot{\mathbf{r}} + m'\ddot{\mathbf{r}}' = 0. \tag{6.8}$$

Integrating yields the conservation of linear momentum as

$$m\dot{\mathbf{r}} + m'\dot{\mathbf{r}}' = \mathbf{p}_o, \tag{6.9}$$

where $\mathbf{p}_o$ is a constant of integration equal to the total linear momentum of the two bodies.

Integrating Eq.(6.9) yields

$$m\mathbf{r} + m'\mathbf{r}' = M\mathbf{r}_{oo} + \mathbf{p}_o t, \tag{6.10}$$

where $M\mathbf{r}_{oo}$ is a constant of integration, where $M = m + m'$ is the total mass of the two bodies and $\mathbf{r}_{oo}$ is the initial position of the center of mass of $\mathbf{r}_o$, defined by

$$\mathbf{r}_o = (m\mathbf{r} + m'\mathbf{r}')/M. \tag{6.11}$$

Multiplying the first of Eqs.(6.7) by r and the second by r' and adding yields

$$f(R)\mathbb{R}\cdot\dot{\mathbb{R}} = m\ddot{\mathbf{r}}\cdot\dot{\mathbf{r}} + m'\ddot{\mathbf{r}}'\cdot\dot{\mathbf{r}}'. \tag{6.12}$$

Integrating this result (6.12) yields the conservation of energy as

$$E = U + m\dot{\mathbf{r}}^2/2 + m'\dot{\mathbf{r}}'^2/2, \tag{6.13}$$

where E is a constant of integration equal to the total energy of the two bodies, U is the potential energy defined by

$$U = - \int_{\infty}^{R} f(R)\mathbb{R}\cdot d\mathbb{R}, \tag{6.14}$$

where the force on the two bodies is assumed to go to zero for the two bodies infinitely separated, and $m\dot{r}^2/2 + m'\dot{r}'^2/2$ is the total kinetic energy of the two bodies.

Since Eqs.(6.7) are of second order in the time derivatives; the solution, $r = r(t)$ and $r' = r'(t)$, must involve 6 constants of the motion each, 3 for the initial position and 3 for the initial velocity. Thus, 12 constants of the motion are necessary to specify the solution to the two body problem.

The conservation of linear momentum, Eq.(6.10), yields 3 constants of the motion given by the 3 components of $p_o$. The initial position of the center of mass, $r_{oo}$, in Eq(6.11) yields 3 further constants of the motion. The conservation of energy, Eq.(6.13), yields the total energy E as 1 additional constant of the motion for a total of 7 constants of the motion.

Three further constants of the motion can be obtained from the conservation of angular momentum. In particular, taking the cross product of r with the first of Eqs.(6.7) and the cross product of $r'$ with the second of of Eqs.(6.7) and adding yields

$$f(R)(r - r') \times \mathbb{R} = 0 = mr \times \ddot{r} + m'r' \times \ddot{r}'. \tag{6.15}$$

This result may be immediately integrated to yield

$$L = mr \times \dot{r} + m'r' \times \dot{r}'. \tag{6.16}$$

where L is a constant of integration equal to the total angular momentum of the two bodies with respect to the arbitrary common origin used to define r and $r'$.

Together with the total angular momentum L 10 of the required 12 constants of the motion have been found. The final 2 constants of the motion can be obtained in principle when f(R) is prescribed as a known specific function of R.

6.2b Classical center of mass coordinates - The classical two body motion may be conveniently separated into the motion of a single



pseudo-body of reduced mass moving about the center of mass, together with a uniform velocity of the center of mass. In particular, this can be accomplished by introducing the center of mass $r_o$ defined by Eq.(6.11). The position of the two bodies relative to the center of mass are then given by

$$\rho = r - r_o = m'\mathbb{R}/M, \qquad \rho' = r_o - r' = m\mathbb{R}/M, \tag{6.17}$$

where $\mathbb{R} = r - r'$.

Rewriting Newton's second law for the two bodies, as given by Eqs.(6.7), in terms of the center of mass coordinates, Eqs.(6.17), yields

$$F = m\ddot{r} = m(\ddot{\rho} + \ddot{r}_o), \qquad F' = m'\ddot{r}' = m'(\ddot{r}_o - \ddot{\rho}'). \tag{6.18}$$

Adding these two equations and noting from Eqs.(6.17) that $m\ddot{\rho} = m'\ddot{\rho}'$ and from Eq.(6.5) that $F = -F'$, yields

$$0 = M\ddot{r}_o. \tag{6.19}$$

Integrating yields the constant velocity motion for the center of mass,

$$r_o = r_{oo} + \dot{r}_o t, \tag{6.20}$$

where $r_{oo}$ is the initial position and $\dot{r}_o = v_o$ is the initial velocity of the center of mass.

Multiplying the first of Eqs.(6.18) by m' and the second by m and subtracting yields

$$F = \mu(\ddot{\rho} + \ddot{\rho}') = \mu\ddot{\mathbb{R}}, \tag{6.21}$$

where the reduced mass $\mu$ is

$$\mu = mm'/(m + m') \tag{6.22}$$

Multiplying Eq.(6.21) by $\dot{\mathbb{R}}$ and integrating yields the internal energy integral of the motion as

$$E' = U + \mu\dot{\mathbb{R}}^2/2, \tag{6.23}$$

where the potential U is again defined by Eq.(6.14) and E' is a constant of integration equal to the internal portion of the total energy. The total energy E is given by

$$E = E' + M\dot{r}_o^2/2, \tag{6.24}$$

where $\dot{r}_o$ is the velocity of the center of mass. This result (6.24)

may be seen to agree with Eq.(6.13) for E by substituting the definition of $\mathbf{r}_o$, Eq.(6.11) and $\mathbf{R} = \mathbf{r} - \mathbf{r}'$ into Eq.(6.24).

In terms of the center of mass 7 constants of the motion, of the required 12, have been found: 3 for $\mathbf{r}_{oo}$, 3 for $\dot{\mathbf{r}}_o$, and 1 for E'.

Introducing center of mass coordinates from Eqs.(6.17) into the expression (6.16) for the angular momentum L yields

$$\mathbf{L} = M\mathbf{r}_o \times \dot{\mathbf{r}}_o + \mu\mathbf{R} \times \dot{\mathbf{R}}, \tag{6.25}$$

where the angular momentum with respect to the arbitrary origin, defined by $\mathbf{r}_{oo}$, due to the uniform motion of the center of mass, as given by Eq.(6.20), is

$$\mathbf{L}_o = M\mathbf{r}_o \times \mathbf{r}_o = M(\mathbf{r}_{oo} + \dot{\mathbf{r}}_o t) \times \dot{\mathbf{r}}_o = M\mathbf{r}_{oo} \times \dot{\mathbf{r}}_o, \tag{6.26}$$

a constant of the motion. The constant internal angular momentum with respect to the center of mass is

$$\mathbf{L}' = \mu\mathbf{R} \times \dot{\mathbf{R}}. \tag{6.27}$$

The total angular momentun L, Eq.(6.16), then becomes

$$\mathbf{L} = \mathbf{L}_o + \mathbf{L}'. \tag{6.28}$$

The internal angular momentum L' yields 3 further constants of the motion.

It may be noted that, since R and $\dot{\mathbf{R}}$ are both perpendicular to L', the motion given in terms of R is confined to a plane. The initial radial and angular position in this plane (obtained by integrating Eq.(6.23) using (6.27)) then provide the remaining necessary 2 constants of the motion. The classical Newtonian two body problem can, thus, be solved in principle once a particular expression for U, Eq.(6.14), is prescribed.

## 6.3 The Neomechanical Two Body Problem

Having indicated how the classical Newtonian two body problem can be solved, an analogous procedure for neomechanics can now be indicated (Wesley 1997). The procedure must be analogous, because at every step of the analysis the Newtonian expressions should be obtainable by allowing $v^2/c^2 \to 0$ and $v'^2/c^2 \to 0$.



6.3a Newton's second law for neomechanics and the integrals of the motion - For a body of mass m at r with a velocity v and a body of mass m' at r' with a velocity v' Newton's second law for neomechanics, replacing m by $m\gamma$ and m' by $m'\gamma'$, becomes

$$\mathbf{F} = d(m\gamma\mathbf{v})/dt, \qquad \mathbf{F}' = d(m'\gamma'\mathbf{v}')/dt, \tag{6.29}$$

where to satisfy Newton's third law the forces are of the form

$$\mathbf{F} = -\mathbf{F}' = f(R)\mathbf{R}, \tag{6.30}$$

where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$ and where

$$\gamma = 1/\sqrt{1 - v^2/c^2}, \qquad \gamma' = 1/\sqrt{1 - v'^2/c^2}. \tag{6.31}$$

Adding Eqs.(6.29), using Eqs.(6.30), and integrating yields the conservation of linear momentum as

$$\mathbf{p}_o = m\gamma\mathbf{v} + m'\gamma'\mathbf{v}', \tag{6.32}$$

where $\mathbf{p}_o$ is a constant of integration equal to the total linear momentum of the system of two bodies. This result (6.32) provides 3 of the required 12 constants of the motion.

Multiplying the first of Es.(6.29) by v and the second by v', using Eq.(6.30), and adding yields

$$\mathbf{v}\cdot d(m\gamma\mathbf{v})/dt + \mathbf{v}'\cdot d(m'\gamma'\mathbf{v}')/dt = f(R)\mathbf{R}\cdot(\mathbf{v} - \mathbf{v}') = f(R)d(R^2/2)/dt. \tag{6.33}$$

This result (6.33) may be integrated to yield the conservation of energy as

$$E = U + c^2 m\gamma + c^2 m'\gamma', \tag{6.34}$$

where E is a constant of integration equal to the total energy and where U, the potential energy, is again defined by Eq.(6.14). Here the constant of integration E has been chosen to include the constant rest energy of the two bodies equal to $c^2m + c^2m'$. This constant rest energy has no influence on the dynamics of the two body problem; it is retained here only because of its essential role for mass energy equivalence. With the constant total energy E 4 constants of the 12 required have been specified: 3 for $\mathbf{p}_o$ and 1 for E.

Taking the cross product of r with the first of Eqs.(6.29) and the cross product of r' with the second and adding yields

$$f(R)(\mathbf{r} \times \mathbf{R} - \mathbf{r}' \times \mathbf{R}) = 0 = (d/dt)(\mathbf{r} \times m\gamma\mathbf{v} + \mathbf{r}' \times m'\gamma'\mathbf{v}'). \quad (6.35)$$

Integrating yields the conservation of angular momentum as

$$\mathbf{L} = \mathbf{r} \times m\gamma\mathbf{v} + \mathbf{r}' \times m'\gamma'\mathbf{v}', \quad (6.36)$$

where $\mathbf{L}$ is a constant of integration equal to the total angular momentum, which together with $\mathbf{p}_o$ and E gives 7 of the required 12 constants of the motion.

The integrals of the motion, Eqs.(5.32), (6.34), and (6.36) represent a set of 7 differential equations of first order in the derivatives of the 6 position coordinates x, y, z, and x', y', z', where one relationship is redundant. In principle they may be integrated to yield $\mathbf{r} = \mathbf{r}(t)$ and $\mathbf{r}' = \mathbf{r}'(t)$, involving 6 constants of integration, the initial positions $\mathbf{r}_o$ and $\mathbf{r}'_o$ of the bodies. Thus, together with the prior 7 constants, the problem is in principle solvable (with one redundant constant).

6.3b Neomechanical center of mass coordinates – The neomechanical two body problem does not in general separate into the motion of a single pseudo-body of reduced neomechanical mass moving about the center of mass, together with the motion of the center of mass. However, a partial separation can be achieved by defining a "velocity of the center of mass" as $\dot{\mathbf{r}}_o$, where

$$m\gamma(\dot{\mathbf{r}} - \dot{\mathbf{r}}_o) = m'\gamma'(\dot{\mathbf{r}}_o - \dot{\mathbf{r}}'), \quad (6.35)$$

which, except for the $\gamma$ factors and the time derivatives is the same as the classical expression for the center of mass, Eq.(6.11). Solving Eq.(6.35) for $\dot{\mathbf{r}}_o$ gives

$$\dot{\mathbf{r}}_o = (m\gamma\dot{\mathbf{r}} + m'\gamma'\dot{\mathbf{r}}')/(m\gamma + m'\gamma'), \quad (6.36)$$

which is not a constant of the motion. It may be noted that the quantity in the denominator of Eq.(6.36) may be obtained from the conservation of energy, Eq.(6.34) as

$$m\gamma + m'\gamma' = (E - U)/c^2, \quad (6.37)$$

where E is a constant of the motion and U is a function of R only.

The velocities of the two bodies relative to the "center of mass" become

$$\dot{\boldsymbol{\rho}} = \dot{\mathbf{r}} - \dot{\mathbf{r}}_o = m'\gamma'\dot{\mathbf{R}}/M\gamma_o, \qquad \dot{\boldsymbol{\rho}} = \dot{\mathbf{r}}_o - \dot{\mathbf{r}}' = m\gamma\dot{\mathbf{R}}/M\gamma_o, \quad (6.38)$$



where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$, $M = m + m'$, and

$$\gamma_o = (m\gamma + m'\gamma')/M. \quad (6.39)$$

The velocities of the individual bodies become

$$\dot{\mathbf{r}} = \dot{\mathbf{r}}_o + m'\gamma'\dot{\mathbf{R}}/M\gamma_o, \qquad \dot{\mathbf{r}}' = \dot{\mathbf{r}}_o - m\gamma\dot{\mathbf{R}}/M\gamma_o. \quad (6.40)$$

Substituting Eqs.(6.40) into Eqs.(6.29) for Newton's second law and adding yields

$$0 = (d/dt)(m\gamma\dot{\mathbf{r}}_o + m'\gamma'\dot{\mathbf{r}}_o). \quad (6.41)$$

Integrating this result (6.41) yields the total linear momentum as a constant of the motion; thus.

$$\mathbf{p}_o = (m\gamma + m'\gamma')\dot{\mathbf{r}}_o = (E - U)\dot{\mathbf{r}}_o/c^2. \quad (6.42)$$

Taking the cross product of $\mathbf{r}_o$ with Eq.(6.41) yields (6.43)

$$\mathbf{r}_o \times (d/dt)\left[(m\gamma + m'\gamma')\dot{\mathbf{r}}_o\right] = (d/dt)\left[\mathbf{r}_o \times (m\gamma + m'\gamma')\dot{\mathbf{r}}_o\right] = 0.$$

Integrating the angular momentum $\mathbf{L}_o$ about the center of mass becomes

$$\mathbf{L}_o = (m\gamma + m'\gamma')\mathbf{r}_o \times \dot{\mathbf{r}}_o = M\gamma_o\mathbf{r}_o \times \dot{\mathbf{r}}_o, \quad (6.44)$$

a constant of the motion. The expression for the total angular momentum, Eq.(6.36), which is a constant of the motion, becomes, using Eqs.(6.40) for r and r', .

$$\mathbf{L} = (m\gamma\mathbf{r} + m'\gamma'\mathbf{r}') \times \dot{\mathbf{r}}_o + \mu\mathbf{R} \times \dot{\mathbf{R}}, \quad (6.45)$$

where the neomechanical reduced mass $\mu$ becomes

$$\mu = mm'\gamma\gamma'/(m\gamma + m'\gamma') = mm'\gamma\gamma'/M\gamma_o, \quad (6.46)$$

which is not a constant of the motion.

Although the total angular momentum L, Eq.(6.45), is a constant of the motion; the individual terms, $\mu\mathbf{R} \times \dot{\mathbf{R}}$ and $(m\gamma\mathbf{r} + m'\gamma'\mathbf{r}') \times \dot{\mathbf{r}}_o$, are not individually constants of the motion. Thus, the total angular momentum L does not separate into a constant internal angular momentum about the center of mass plus a constant angular momentum of the center of mass, as in the classical Newtonian case.

Although the total linear momentum $\mathbf{p}_o$, Eq.(6.42), is a constant of the motion; the center of mass (defined as the time integral of Eq.(6.36)) does not in general move with a constant uniform velocity. In particular,

$$(d/dt)\left|(m\gamma\mathbf{r} + m'\gamma'\mathbf{r}')/(m\gamma + m'\gamma') \neq (m\gamma\mathbf{r} + m'\gamma'\mathbf{r}')/(m\gamma + m'\gamma') = \dot{\mathbf{r}}_o; \right. \tag{6.47}$$

since the $\gamma$'s are functions of the velocities, which in turn are functions of the time.

In conclusion, the neomechanical two body problem does not separate into a problem involving motion about the center of mass plus the motion of the center of mass with a constant uniform velocity.

It may be readily appreciated that all of the expressions derived here for neomechanics reduce to the classical Newtonian limit for the case of $v^2/c^2 \ll 1$ and $v'^2/c^2 \ll 1$, where $\gamma \simeq 1$ and $\gamma' \simeq 1$.

The analysis of the neomechanical two body problem can be carried no further here; although in principle a solution exists, as already indicated above.

CHAPTER 7

# THERMODYNAMIC ORDERING

Man is preoccupied with thermodynamic ordering processes and questions concerning how order can be created from disorder or chaos. How can low entropy life survive in a high entropy environment? How can man then exist? How can the necessary low entropy food be best obtained from high entropy gaseous $CO_2$, water, and salts in solution? What is the direction of evolution of plants and animals over geologic time? Is the Earth becoming more ordered with time; or is it slowly degenerating into disorder and chaos? How can low entropy ore deposits arise? What caused the low entropy Sun to form from a high entropy gas and dust cloud?

One of the most important physical laws to help answer these questions is the "primary law for thermodynamic ordering processes", that states:

> Statistical thermodynamic systems maintained at an absolute temperature T open to a cold sink at an absolute temperature $T_o < T$ proceed toward states of lower entropy or greater thermodynamic order.

(Wesley 1989b, 19911). A most important corollary to this law may be immediately stated. The "primary law for thermodynamic ordering processes in *nature*" states:

> Statistical thermodynamic systems open to deep space with tempertures greater than 2.7°K proceed toward states of lower entropy or greater thermodynamic order.

## 7.1 Conditions for Thermodynamic Systems to Become More Ordered

The primary law for the ordering of a statistical thermodynamic system implies:

1) The system, to maintain a temperature $T > T_o$, must be continually supplied with an influx of low entropy, or high utility energy, such as a heat source at an absolute temperature $T' > T > T_o$.

2) The system must be open, not only to a cold sink, but also to an influx of low entropy or high utility energy.

3) The system, being at a temperature T greater than the cold sink at a temperature $T_o$, must produce an outflow of high entropy or low utility energy.

4) The rate of influx of low entropy and outflow of high entropy are limited, or are governed by, appropriate subsidiary boundary conditions.

5) The system must continually produce entropy equal to the differencew between the rate of outflow of high entropy to the rate of inflow of low entropy.

6) Subsidiary conditions must permit mass transport mechanisms to exist, that allow atoms and molecules in high entropy arrays to be brought into lower entropy arrays.

7) The system must not be already in a lowest entropy state or in a state of maximum thermodynamic order.

## 7.2 The Primary Law for the Creation of Thermodynamic Order and the Second Law of Thermodynamics

It is generally mistakenly felt that *all* statistical thermodynamic systems proceed toward states of higher entropy and disorder; because the second law of thermodynamics states that *closed* statistical thermodynamic systems proceed toward states of higher entropy, or toward thermodynamic disorder. However, the primary law concerns *open* systems and not *closed* systems. For example the Earth's surface is such an open system maintained at an absolute temperature of about 290° by the influx of low entropy sunlight, that is open to deep space as a cold sink of 2.7°K. Essentially all statistical thermodynamic systems on the Earth, including the laboratory itself, are systems at tempertures greater than 2.7°K that are open to deep space. A closed system in nature is extremely rare and is of little



interest.

The second law of thermodynamics may be applied to a *large* closed system containing a *small* local system of interest. The *large* closed system may be regarded as providing the "environment" or the "universe" for the *small* local system of interest. The second law of thermodynamics then says that the net entropy of the *large* closed system plus the *small* local system must increase, which yields

$$\dot{S}(\text{local system}) + \dot{S}(\text{universe}) > 0, \tag{7.1}$$

where dots above the symbols refer to time derivatives or to rates. The rate of ordering of interest is the rate of decrease in the entropy of the local system of interest; thus, from Eq.(7.1),

$$\left[ - \dot{S}(\text{local system}) \right] < + \dot{S}(\text{universe}). \tag{7.2}$$

If the local system of interest experiences an inflow of entropy S(in) from the environment as well as an outflow of entropy into the environemnt S(out), the net increase of entropy of the environment, or "universe", produced by the system is $\dot{S}(\text{universe}) = \dot{S}(\text{out}) - \dot{S}(\text{in})$. The second law of thermodynamics, as given by Eq.(7.2), then becomes

$$\left[ - \dot{S}(\text{local system}) \right] < \dot{S}(\text{universe}) = \dot{S}(\text{out}) - \dot{S}(\text{in}). \tag{7.3}$$

The time rate of increase of the entropy of the universe $\dot{S}(\text{universe}) = \dot{S}(\text{out}) - \dot{S}(\text{in})$ caused by the local system is called the "entropy production", a most important quantity. Not only is the primary law for ordering processes completely compatible with the second law of thermodynamics, the second law of thermodynamics yields a most fundamental condition for ordering processes to occur. The entropy produced (and expelled) by a system must be greater than the rate of ordering of the system itself. In general the entropy production of a system is very much greater than the rate of ordering of the system.

## 7.3 Entropy Production Drives a System Toward Thermodynamic Order

An isolated, closed, or adiabatic thermodynamic system has zero entropy production. According to the second law of thermodynamics

such an adiabatic system cannot increase its thermodynamic order or reduce its entropy. The entropy of such a closed system must increase with time producing thermodynamic disorder. If a system has a negative entropy production, more entropy flowing into than out of the system, then the system has a rate of entropy increase, or a rate of disordering, even greater than that of an isolated or adiabatic system. Such a negative entropy producing system will heat up, the sink being effectively at a higher temperature than the source.

From Eq.(7.3) it may be appreciated that the larger the entropy production, the larger the rate of ordering can be. Thus, to produce ordering in a thermodynamic system the entropy produced by the system should be made as large as possible. The statistical or thermodynamic "force" or "potential" that drives a system toward thermodynamic order may be thus taken as the *entropy production*. No statistical thermodynamic system can spontaneously proceed to a state of more order or lower entropy. The system must produce entropy in order to increase its thermodynamic order or to decrease its entropy.

One hears of "self organizing systems", that are apparently supposed to be systems that can somehow spontaneously increase their thermodynamic order all by themselves. This is quite impossible; a system must be driven by entropy production to become ordered. However, it is true that the pattern or the template that determines the nature of the order is in general provided by a seed crystal, a zygote, or a seed, or an egg cell upon which molecules assemble to grow into large orderly arrays. Thus, although the pattern for the order may be said to be in the system itself; the thermodynamic ordering achieved is only by virtue of entropy production.

## 7.4 Irreversible Thermodynamics

"Irreversible thermodynamics" involves statistical systems in which a temperature can be defined and where parameters characterizing the system may change explicitly with time. "Traditional thermodynamics" does not involve the time. Systems are assumed to be in equilibrium with no macrosopic property changing with time. "Traditional thermodynamic" processes are assumed to take place



reversibly or infinitely slowly, so that time rates are not involved. "traditional thermodynamics" should be properly renamed "thermostatics".

*Traditionally* the subject of irreversible thermodynamics has been unfortunately limited to the idea that it is possible to extrapolate from "thermostatics" for states only differentially displaced from equilibrium to obtain valid laws for irreversible thermodynamics (de Groot 1952, Prigogine 1961, Donnelly et al 1966). This idea seems like a logical and promising way to proceed into the area of irreversible thermodynamics. Unfortunately, this approach has been strangely and singularly unsuccessful. For example, the Onsager (1931) relations claiming the matrix of diffusion coefficients for simultaneous diffusion processes is symmetric is simply experimentally false. There is no need to present this traditional unsuccessful approach to irreversible thermodynamics here.

Thermostatics, or "traditional thermodynamics" can be used to establish certain limitations or boundary conditions for irreversible thermodynamics (as already indicated in Section 7.2 above); but the end equilibrium time-independent states do not tell much about the dynamics of systems as they change as a function of time far from equilibrium (or even close to equilibrium!).

## 7.5 Evaluation of the Performance of Irreversible Heat Engines

The failure to consider phenomena involving the time and time rates for statistical thermodynamic systems has had rather drastic consequences for the progress of science, for engineering, for economics, and for many other aspects of human activity. In general traditional investigations of statistical thermodynamic systems have been limited to phenomena that do not involve the time explicitly such as traditional thermodynamics. Statistical mechanics, involving the dynamics of a large collection of molecules, has been primarily successful only in yielding equilibrium states, where no explicit time changes or rates are involved.

Thus, traditionally the performance of heat engines has been limited to the efficiency $\eta$, defined as the ratio of the net work

W performed to the heat Q(in) supplied; thus,

$$\eta = W/Q(in). \tag{7.4}$$

This measure ignores all *rate* processes; yet real heat engines perform at nonzero *time rates*. The performance of real heat engines cannot be properly evaluated in terms of static quantities alone, such as $\eta$, the net work done W for the heat Q(in) supplied; actual time rates *must* be considered.

A proper evaluation of the performance of actual heat engines operating at finite rates is a problem for irreversible thermodynamics, and not for thermostatics, or "traditional thermodynamics". Engineers responsible for the design of heat engines, persist upon using static efficiencies, such as Eq.(7.4); which makes it impossible for them to design heat engines for optimal performance from first principles. The design of heat engines has, thus, remained a haphazard *art* with little physics involved.

To evaluate the performance of an actual heat engine operating at a finite rate it is first necessary to place a *value* on the *rate* that work is done (not necessarily the immediate power, but the over-all long-time average rate of doing work). Secondly, it is necessary to place a *value* on the *rate* that heat is used to create the *rate* of work delivered. Since work constitutes energy of the highest utility (as it can create the greatest amount of thermodynamic order, as explained in Section 7.6 below); work (or mechanical energy) may be taken as a standard for the *value* of energy in general. In economic language the rate that work is performed can be evaluated in terms of the rate that revenue is received by virtue of the rate of doing work. The rate of *profit* $\dot{R}$ of operating the heat engine is then given by

$$\dot{R} = \dot{W} - b\dot{Q}(in), \tag{7.5}$$

where b is the *cost* per unit energy rate consumed, $\dot{Q}(in)$, to create the rate of work done $\dot{W}$. In economic language, the rate of *profit* $\dot{R}$ equals the rate of revenue income minus the cost rate.

The coefficient b may include all costs associated with the rate energy is supplied, including the costs to buy, or manufacture, the engine amortized in terms of the rate that heat energy is



delivered.

A proper measure for the performance of a heat engine must necessarily be an extensive quantity, such as the rate of profit $\dot{R}$, Eq.(7.5). A ratio, such as the traditional efficiency $\eta$, Eq.(7.4), cannot provide a proper measure for the performance of a heat engine; because maximizing the ratio may mean the minimization of the denominator. And minimizing the denominator, that can be a function of the design parameters of the heat engine, need not be reasonable. For example, maximizing the traditional efficiency $\eta = W/Q(in)$ can mean the minimization of Q(in); so that, when $\eta$ is a maximum W can be zero (as is actually the case for the ideal Carnot engine!). The rate of profit $\dot{R}$ is a proper extensive quantity that can be maximized to yield the optimum design and mode of operation for a heat engine.

Alternative extensive measures for the performance of actual heat engines might also be chosen that are adequate; but the rate of profit $\dot{R}$, Eq.(7.5), is probably the simplest. Whatever measure might be chosen, it must take into account the fact that actual heat engines, operating at nonzero rates, necessarily involve irreversible thermodynamic phenomena, such as friction. Static measures of performance can never be sufficient.

For animals (including man) operating as heat engines, the measure of performance given by $\dot{R}$, Eq.(7.5), is clearly superior to the traditional static efficiency $\eta$, Eq.(7.4); because the basal metabolic rate of animals involves an inescapable cost rate minimum for an animal's nourishment. Thus, only the *time rate* of doing work by an animal (or equivalently the *time rate* of entropy reduction by plants) minus the cost rate to feed the animal can be of interest. Maximizing $\dot{R}$ yields the strategies necessary to optimize the overall rate that an animal can do work (and the rate of entropy reduction produced by plants).

It may be noted that machines, as well as animals, entail an energy cost rate that is not directly involved with doing work. The manufacture of an engine requires an expenditure of high utility energy that results in an initial cost, that may be amortized in terms of the rate of energy input to the engine. In addition,

repairs and servicing are required to keep an engine functioning. Thus, precisely as for animals and plants, there is always an inescapable basic energy rate cost that is largely independent of the rate that work is done. The measure of the performance of an actual heat engine must include the basic energy costs associated with manufacturing, or buying, and maintaining the engine.

## 7.6 Mechanical Work Can Create the Maximum Thermodynamic Order

The second law of thermodynamics yields the conclusion that the maximum work dW that can be achieved by a heat engine operating cyclic between a hot source at an absolute temperature $T_1$ and a cold sink at an absolute temperature $T_o$ is that given by an idealized Carnot engine operating reversibly. The maximum, or Carnot, efficiency $\eta_c$ is given by

$$\eta_c = dW/dQ(in) = 1 - T_o/T_1, \tag{7.6}$$

where Q(in) is the heat extracted from the hot source. In particular, this result (7.6) follows from an idealized device that in principle can operate with zero entropy production; thus,

$$dS(out) - dS(in) = 0 = dQ(out)/T_o - dQ(in)/T_1. \tag{7.7}$$

The heat out must equal the heat in minus the work performed; so

$$dQ(out) = dQ(in) - dW. \tag{7.8}$$

Substituting Eq.(7.8) into (7.7) and solving for dW/dQ(in) then yields Eq.(7.6).

A cyclic process that has zero entropy production remains with the same net entropy at the end of a cycle as at the beginning. If all of the heat from the hot source were to be passed directly to the cold sink, there would be a net entropy increase given by

$$dQ(in)(1/T_o - 1/T_1) > 0; \tag{7.9}$$

but for a reversible process that produces no entropy there would have to be a corresponding entropy reduction equal to

$$dS = - dQ(in)(1/T_o - 1/T_1). \tag{7.10}$$

Since the net entropy change in any real process can be no less



than zero; ( - dS) represents the maximum entropy decrease, or the maximum thermodynamic order, that can be achieved. From Eq.(7.6) for the maximum amount of work that can be done Eq.(7.10) becomes

$$dW/T_o = ( - dS). \tag{7.11}$$

This means that the maximum work created corresponds to an entropy decrease ( - dS). Conversely this means for reversible processes that the work dW can be used to create the maximum amount of thermodynamic order given by

$$dW(applied) = ( - dST_o)(max). \tag{7.12}$$

It may be concluded that mechanical work (or other forms of mechanical energy) represent energy with the greatest capacity for creating thermodynamic order or for creating the greatest entropy reduction.

## 7.7 The Utility of Different Forms of Energy

In ordinary language one speaks of *consuming* energy; as though the energy were destroyed in the act of consumption. But energy is conserved. It cannot be destroyed. In particular, energy is "consumed" when it passes from a state of high "utility" to a state of low "utility". A hot thermal source of energy can be used to yield useful work if a portion of the energy is discarded to a cold sink. Thus, the "utility" $\mu$ of hot thermal energy may be defined as the fraction of the energy that can be converted to useful work. The largest fraction of the thermal energy at a temperature $T_1$ that can be converted to useful work with a cold sink available at the temperature $T_o$ is given by the Carnot efficiency $\eta_c$; thus,

$$\mu(max) = \eta_c(Carnot) = 1 - T_o/T_1. \tag{7.11}$$

The actual utiltiy of thermal energy will, of course, be less than this maximum value. The actual utility depends upon the actual heat engine available and upon how it is employed.

The "utility" of any energy source may be defined as the fraction of the energy that can in principle be converted to mechanical work; thus,

$$\mu = Q/W. \tag{7.12}$$

The utility of mechanical work, mechanical potential energy, and mechanical kinetic energy are all unity. The "utility" is intended as a practical measure that depends upon the particular circumstances that permit a conversion of the energy of interest to mechanical work.

The "cost" of a particular form of energy, such as thermal energy, that is used to evaluate the perfomance of a heat engine as the rate of profit, Eq.(7.5), may be in general taken to be proportional to the utility of the energy. The concept of the utility of a particular form of energy is important; as it is a measure of the amount of thermodynamic order that the energy can create, or the amount of entropy reduction that can be achieved pro unit energy expended.

Entropy production, Eq.(7.3), that is so important to create and to maintain thermodynamic order, may be viewed as a degradation of the utility of energy from a state of high utility to a state of low utility.

## 7.8 An Irreversible Heat Engine Consisting of a Carnot Engine Plus a Heat Exchanger

To illustrate the need to consider time and time rates, or irreversible thermodynamics, to evaluate the performance of a heat engine a specific example may be considered, where the heat engine consists of an ideal Carnot engine that is supplied heat through a heat exchanger, as diagrammed in Fig. 7.1. The rate that heat can flow through the heat exchanger is taken to be proportional to the temperature difference across the exchanger; thus,

$$Q = K(T - T_1), \tag{7.13}$$

where $T > T_1$.

Since the heat dQ entering the heat exchanger has an entropy dQ/T and the entropy of the same amount of heat leaving the heat exchanger is $dQ/T_1$; there is an entropy increase in the heat exchanger given by

$$0 < dS = dQ(1/T_1 - 1/T). \tag{7.14}$$

Since the entropy increase has nothing to do with the performance



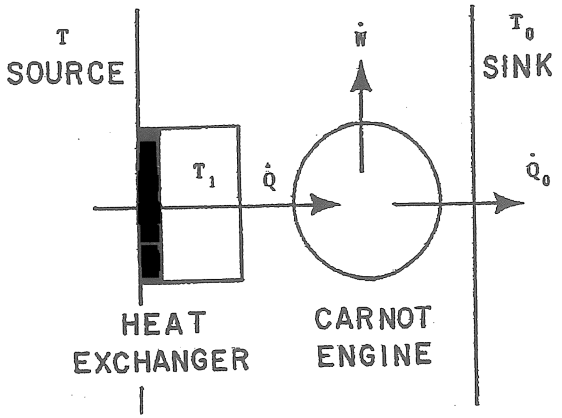



Fig. 7.1 An irreversible heat engine consisting of an ideal Carnot engine plus a heat exchanger.

of the ideal Carnot engine; the overall device of heat exchanger plus Carnot engine must have an efficiency, $\eta = W/Q$, that is less than the Carnot efficiency $\eta_c$.

The performance of this device, as given by the rate of profit R, Eq.(7.5), becomes

$$\dot{R} = \dot{W} - b\dot{Q} = \dot{W} - bK(T - T_1), \tag{7.15}$$

where the cost parameter $b < 1$. The rate of work done by the Carnot engine is given by

$$\dot{W} = \dot{Q}(1 - T_o/T_1) = K(T - T_1)(1 - T_o/T_1); \tag{7.16}$$

so the time rate of profit from Eq.(7.16) and (7.15) becomes

$$\dot{R} = K(T - T_1)(1 - b - T_o/T_1). \tag{7.17}$$

The temperature $T_1$ may be regarded as an adjustable parameter. The maximum time rate of profit as a function ot $T_1$ is then given by

$$d\dot{R}/dT_1 = 0, \tag{7.18}$$

which yields $T_1^*$ for the maximum rate of profit as

$$T_1^* = \sqrt{T T_o/(1 - b)} \ . \qquad (7.19)$$

Substituting this result (7.19) into Eq.(7.17) yields the maximum rate of profit as

$$\dot{R}(\max) = K T (\sqrt{1 - b} - \sqrt{T_o/T})^2 \ . \qquad (7.20)$$

Instead of $T_1$ as an adjustable parameter the static efficiency $\eta = W/Q$ may be introduced as an adjustable parameter. In terms of $\eta$ the time rate of profit, Eq.(7.17), using (7.16), becomes

$$\dot{R} = K T (\eta_c - \eta)(\eta - b)/(1 - \eta), \qquad (7.21)$$

where $\eta_c$ is the efficiency of a Carnot engine operating between the source temperature T and the sink temperature $T_o$, as if no heat exchanger were present. The rate of profit R, as given by Eq.(7.21), is shown in Fig. 7.2 for b = 0.1 and $\eta_c$ = 0.7.

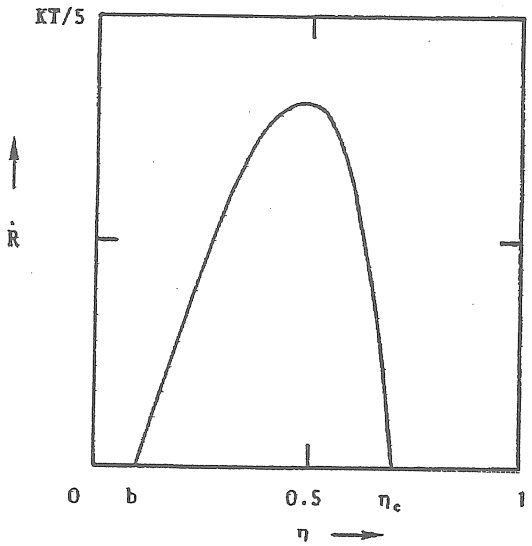



Fig. 7.2 The time rate of profit R as a function of the traditional efficiency $\eta$, Eq.(7.21), for the irreversible heat engine indicated in Fig. 7.1 for the case b = 0.1 and $\eta_c$ = 0.7.



It is important to note that for larger values of the efficiency the rate of profit R declines with increasing efficiency, going to zero for the maximum Carnot efficiency. This should not be surprising; as a heat engine operating reversibly, and thus infinitely slowly, must do work at a zero rate. A Carnot engine is worthless. Clearly the efficiency, $\eta = W/Q$, is not an appropriate measure for the performance of a heat engine.

Ways to improve the performance of the heat engine diagrammed in Fig. 7.1 are immediately suggested by the time rate of profit R, Eq.(7.17). If, for example, the coefficient K is increased, the rate of profit is increased; so the heat exchanger should be made as large as possible from material of the greatest thermal conductivity.

## 7.9 Order, Complexity, Etc.

Words having different meanings in different contexts can lead to confusion and possible false conclusions. Since such terms as "order" and "complexity" are used in *different* contexts to mean quite *different* things; it is necessary to define precisely these terms as used in the statistical thermodynamical sense. A "microstate" refers to a complete detailed description of a statistical thermodnamic system, giving the positions, momenta, and state of each and every molecule of every sort in the system. A "macrostate" refers to the state of a statistical thermodynamic in terms of macroscopically observed mean quantities, such as the temperature and pressure of a gas.

"Thermodynamic order" refers to the microstate of a system in which the positions, momenta, and states of individual molecules are correlated with each other, so that fewer statements are necessary to specify the system completely in detail microscopically.

"Entropy" is an extensive macrosopic measure of the thermodynamic order of a system. The lower the entropy, the greater the order; and the greater the entropy, the less the thermodynamic order, or the greater the chaos.

"Thermodynamic probability" is a macroscopic measure of the likelihood of a particular macrostate relative to all of the possible

microstates that can yield the same apparent macrostate. Thus, an isolated system will move "spontaneously" toward a state of greatest "probability", the greatest entropy, or the greatest disorder.

"Information" per se has no relevancy to statistical thermodynamics; although the specification of a state of disorder, or high entropy, requires more statements, or more "information" to specifiy. The arbitrary rules of "information theory" correspond to no physical laws; so the occassional attempts to impose "information theory" upon *physics* leads to false conclusions.

"Complexity" refers microscopically, or thermodynamically, to a state of disorder, or high entropy. Macroscopically "complexity" refers to complicated systems composed of many different individual macroscopic parts. A "complex" macrosystem may be thermodynamically, or microscopically quite *simple* or ordered and not "complex". For example, a "complex" automobile motor with many different individual macroscopic parts is composed essentially of low entropy crystalline iron, that is thermodynamically, or microscopically, *simple*, ordered, and not "complex". A dog is a "complex organism, when viewed macroscopically; but a dog (as well as life in general) is composed of atoms and molecules arranged in compounds of lower entropy than these atoms and molecules as originally found in the environment. Microscopically, or thermodynamically, a dog (and life in general) must be viewed as a *simple* system, that is not "complex".

A monatomic gas in an adiabatic container that is in thermodynamic equilibrium at a state of maximum entropy, or maximum disorder is a very "complex" system in the statistical thermodynamic sense, requiring many statements to specify the positions and momenta of all of the atoms in the system. Yet macroscopically the system may be viewed as a very *simple* system with no "complexity"; as it can be described macroscopically by specifying merely the volume, pressure, and temperature.

## 7.10 Origin of a Low Entropy Star from a High Entropy Gas Cloud

The great importance of the primary law for thermodynamic ordering processes is indicated by its general applicability. It is



not only applicable and of value on a local scale; it is also applicable and of value on a global or cosmological scale. It is thus of interest to examine the example of a low entropy star condensing out of a high entropy gas cloud.

The entropy per mole of an ideal monatomic gas of a fixed total mass and density $\rho$ is given by

$$s = s_o + R\,ln\,(T^{3/2}/\rho), \tag{7.22}$$

(Sears 1953) where R is the ideal gas constant equal to 8.32 joules/mole and $s_o$ is an arbitrary reference constant. The change in entropy, $\Delta s$, per unit mass of an initial monatomic interstellar hydrogen gas cloud with a density of $\rho_i = 10^{-23}$ gm/cm and absolute temperature $T_i = 15°K$ and with a total mass $M = 2 \times 10^{33}$ gm condensing into a star with a final density $\rho_f = 1.4$ gm/cm and final absolute temperature $T_f = 10^7$ °K, as given by Eq.(7.22), is

$$\Delta s = -\,275 \text{ joule/gm°K}. \tag{7.23}$$

Thus, the mass of a star is more thermodynamically ordered than the same mass when in the original interstellar gas cloud. The important question is then: How does this ordering occur, seemingly in contradiction to the second law of thermodynamics?

To answer this question it is necessary to consider the process in more detail. It may be assumed that at sometime a random fluctuation in the monatomic hydrogen gas cloud will result in a momentary accumulation of atoms in a small volume. This accumulation can then gravitationally attract neighboring atoms. The neighboring atoms will then be accelerated toward the accumulation. Some of these neighboring atoms will suffer collisions with other atoms, whereby some of their kinetic energy gained by the gravitational attraction is radiated off into deep space as thermal energy. Having lost kinetic energy they can no longer escape out of the gravitational potential well produced by the original accumulation. Thus, neighboring atoms can become trapped to add to the original accumulation of atoms. The process may be envisioned to continue until sufficient mass has accumulated to form a star.

The high utility energy that drives this ordering process is provided by the gravitational potential energy of unit utility of

the atoms in the original gas cloud. The net entropy per unit mass $\Delta s^*$ that must be radiated off into deep space in order to produce the condensation is then given by the gravitational potential energy dissipated as thermal energy radiated off into deep space at a mean temperature of the condensing gas cloud of perhaps T = 1000°K; thus

$$\Delta s^* = \Delta U(\text{gravitation})/MT. \tag{7.24}$$

The amount of gravitational potential energy per unit mass that must be dissipated to form a star of mass M and radius R is given by

$$\Delta U(\text{gravitation})/M = 3GM/5R\ . \tag{7.25}$$

For a typical star of mass $M = 2 \times 10^{33}$ gm and radius $R = 6 \times 10^{10}$ cm Eq.(7.25) yields

$$\Delta U(\text{gravitation})/M = 1.33 \times 10^{8} \text{ joules/gm}. \tag{7.26}$$

For a mean temperature of T = 1000°K the waste entropy per unit mass radiated off into deep space is then

$$\Delta s^*(\text{radiated}) = \Delta U/MT = 1.3 \times 10^{5} \text{ joule/gm°K}. \tag{7.27}$$

This is also the net entropy production per unit mass dissipated in order to create the thermodynamic order, or the entropy reduction per unit mass given by Eq.(7.23). The entropy dissipated is about 500 times greater than the entropy reduction. Thus, stellar formation from a high entropy gas cloud obeys the law for thermodynamic ordering processes; and it does not contradict the second law of thermodynamics.

Even after a stable star is formed by high utility gravitational energy being dissipated as low utility thermal energy into deep space, the star continues to decrease its internal entropy by dissipating its internal high utility nuclear energy to thermal energy of the temperature of the stars surface. According to usual speculation the star is supposed to evolve into a white dwarf, where the internal matter becomes highly ordered as a crystalline array of nucleons and electrons crushed together at an extremely high density. The entire evolution of a star from an interstellar gas cloud to a white dwarf is a continual process of entropy reduction achieved by virtue of a contintual higher entropy production in agreement with the prinmary law for thermodynamic ordering processes.



## 7.11 The Solar System Has Evolved from High Entropy Gas and Dust

Not only is the Sun a low entropy condensation from high entropy gas and dust; the entire solar system is thermodynamically ordered in comparison to the original high entropy gas and dust from which it arose. The entropy of the matter in planets, moons, and asteroids, being in a solid high density state, is very much lower than the original gases and dust from which the matter was formed.

The Earth's moon and meteorites reveal low entropy crystals of atoms and molecules in ordered arrays that are drastically different from a gaseous random distribution of these same atoms and molecules. Some meteorites are high in carbon; while others are high in iron and nickel; so there has been an entropy reduction from a state in which carbon atoms are randomly mixed with iron and nickel atoms to a state in which they are separated.

As a hitch-hiker from the back of a pickup truck in 1934 I witnessed the fall of a spectacular copper meteorite that subtended a visual angle of about 1/4th that of the full moon. It travelled from west to east and disappeared below the horizon. The driver of the pickup was so shocked by the brilliant blue-green light that suddenly illuminated the entire landscape that he swerved from the highway, came to a stop, jumped out, and gasped, "My God! What was that?" I assured him that it was only a meteorite. The most curious aspect of this event is the fact that copper represents only about $6 \times 10^{-9}$ of the mass of the matter in interstellar space. So what was the detailed mechanism that could bring together so many hundreds of grams of copper in *one* meteorite? Such extremely highly thermodynamically ordered material implies the existence of highly effective ordering processes in the formation of the cold material of the solar system. Apparently this ordering of cold matter was also powered by the dissipation of the original gravitational infall energy that gave rise to the solar system.

The fact that the Earth seems to be composed of about $6 \times 10^{-2}$ iron and only $3 \times 10^{-7}$ of the interstellar matter is iron (and $2.5 \times 10^{-5}$ of the sun's matter is iron) indicates massive thermodynamic ordering of the entire Earth, in addition to the fact that

the Earth is in a dense solid state of low entropy as compared with the original gaseous state.

The thermodynamic ordering of the cold matter in the solar system is perhaps best accounted for by the condensation of gases exhaled, or spun off, from the primordial Sun. Such hot gases, radiating off their thermal energy into deep space, could cool off and condense out preferentially on seed crystals to contribute to the growth of larger solid crystals. The thermodynamic ordering of the cold matter in the solar system would then be powered by the thermal energy of the hot gases exhaled, or spun off, from the primordial Sun. Since the transparency and temperature of such gases would vary as the distance from the Sun; there should be a fractional distillation and condensation of elements and compounds as a function of their distance from the Sun. The Earth is perhaps at a distance from the Sun that is preferentially favored for the condensation of iron. Perhaps the hot solar wind of today is a continuation of this process.

The thermal energy inside of the Earth is probably primarily fossil gravitational infall energy. This energy, flowing out through the surface of the Earth into deep space, provides a system that can, in principle, produce thermodynamic order within the Earth. Thus, percolating processes within the Earth, powered by the Earth's thermal energy can sponsor the formation of ores and concentrations of low entropy compounds. Since only a relative small entropy production is involved; the Earth's thermal energy can produce only a relatively slow rate of entropy reduction.

At least 90% of the mass of the solar system is hydrogen in the Sun. Yet only about $2 \times 10^{-7}$ of the Earth's mass is composed of hydrogen. Such a drastic separation of elements within the solar system also indicates the highly thermodynamically ordered state of the solar system.

It is, of course, possible to give numerical estimates of the entropy reduction associated with the various thermodynamic ordered systems in the solar system and to estimate the net entropy production that gave rise to these ordered states; but such research would be too voluminous for the present book.



## 7.12 Thermodynamic Ordering of the Earth's Surface Powered by Sunlight

Since the Earth condensed out into a solid sphere about $4.5 \times 10^9$ years ago; thermodynamic ordering processes on the Earth's surface have proceeded primarily by virtue of irradiation by sunlight. Sunlight is a source of high utility thermal energy at the temperature of the Sun's surface of $T_s = 5800°K$. This energy is reradiated from the Earth's surface as low utility thermal energy at a temperature of about $T_e = 290°K$. Thus, by virtue of irradiation by sunlight the Earth's surface is a system that produces entropy. According to the primary law for thermodynamic ordering processes it must thus proceed toward more thermodynamic order, or lower entropy. In particular, the entropy of sunlight of energy $\Delta Q$ arriving on the Earth is $\Delta S_i = \Delta Q/T_s$; and the entropy of the same amount of energy radiated from the Earth off into deep space is $\Delta S_o = \Delta Q/T_e$; so the entropy produced is

$$\Delta S_s(\text{produced}) = \Delta S_o - \Delta S_i = \Delta Q(1/T_e - 1/T_s). \tag{7.28}$$

On a cosmogonic scale it is of interest to examine the total entropy produced by sunlight since the Earth was formed 4.5 milliard (a billion in the US) years ago. Assuming that the sun has always irradiated the Earth at the rate that is observed today of 0.136 joule/cm$^2$/s, the total solar energy received on the Earth since it condensed out as a solid sphere is

$$\Delta Q = 2.5 \times 10^{34} \text{ joule} \tag{7.29}$$

From Eq.(7.28) the total entropy produced is then

$$\Delta S_s(\text{produced}) = 8.1 \times 10^{31} \text{ joule/°K} \tag{7.30}$$

This may be compared with the total entropy produced by the dissipation of gravitational infall energy to form the entire Earth, which from Es.(7.24) and (7.25) is given by

$$\Delta S_e(\text{produced}) = 3GM_e^2/5R_eT_e = 8.2 \times 10^{29} \text{ joule/°K}. \tag{7.31}$$

The total entropy produced by sunlight is, thus, two orders of magnitude greater than the total entropy produced by the dissipation of gravitational infall energy to form the entire Earth.

In addition, the thermodynamic order created by sunlight involves

only the outer surface, or lithosphere (defined here as the outer shell to a depth of 5 km), of the Earth; whereas, the infall energy involved the ordering of the entire Earth from the center to the surface. It may be thus concluded that the surface, or lithosphere, of the Earth must be much more thermodnamically ordered than the interior of the Earth.

## 7.13 The Role of Life in the Thermodynamic Ordering of the Earth's Surface

Life has played a most significant role in the thermodynamic ordering of the Earth's surface (Wesley 1989b). High entropy substances in the environement are converted to low entropy compounds in living organisms.

7.13a Life is composed of elements and thus compounds of the lowest entropy - It is probably significant that life on the Earth is based upon elements with the lowest entropies (and the lowest heat capacities at constant pressure $c_p$), namely carbon with the lowest entropy of all of the elements, hydrogen with the next lowest entropy, and oxygen with the fourth lowest entropy. According to Kopp's rule the heat capacity of a compound is given approximately by the sum of the heat capacities of its constituent elements, $c_p = \Sigma_i c_{pi}$. Applying the third law of thermodynamics the entropy of a compound can, thus, be roughly estimated as the sum of the entropies of its constituent elements. The entropy per mole of a compound s is then roughly given by

$$s = \Sigma_i \int_o^T c_{pi}\, d(ln\, T) = \Sigma_i s_i , \qquad (7.32)$$

where T is the absolute temperature. Compounds composed of elements with the lowest entropies will, thus, tend themselves to have lower entropies.

7.13b Photosynthesis is an entropy reducing process - The all important necessary initial process whereby life reduces entropy is photosynthesis. Photosynthesis today converts high entropy gaseous carbon dioxide, $CO_2$, and high entropy liquid water into low entropy solid carbohydrates and gaseous oxygen; thus,



$$nCO_2 + mH_2O \rightarrow C_n(H_2O)_m + nO_2 , \qquad (7.33)$$

where n and m are integers. The entropy reduction achieved may be estimated by considering the reverse process involving the oxidation, or burning, of the carbohydrate. The oxidation involves essentially an oxidation of the carbon alone (the water released being returned to the environment). The heat of oxidation of carbon is $\Delta Q = 3.33 \times 10^4$ joule/gm of carbon. The entropy reduction achieved in an environment with the temperature $T_e = 290°K$ per gram of carbon fixed by photosynthesis is then

$$(-\Delta S) = \Delta Q/T_e = 114 \text{ joule/gm°K}. \qquad (7.34)$$

It may be assumed that other photosynthetic entropy reducing processes existed in the past that were not at all similar to what is known today. Some sort of photosynthesis undoubtedly existed from the very origin of the Earth. The early photosynthetic processes were probably simple. The more successful processes, being able to produce ordered compounds at a faster rate, then displaced the less successful processes. Sunlight compelled or forced ever better entropy reducing mechanisms. Competition among various possibilities must have finally evolved the chlorophyll and chloroplasts of today.

It is estimated that plants can store about 2% of the solar energy in the plants. This means that entropy production created by the dissipation of solar energy at 5800°K to 290°K, that is involved in present-day photosynthesis, compared with the entropy reduction achieved by green plants is given by

$$dQ(1/T_e - 1/T_s)/(0.02dQ/T_e) = 48. \qquad (7.35)$$

The primary law for thermodynamic ordering processes is thereby obeyed.

7.13c The oxygen in the atmosphere is evidence of the importance of life for the thermodynamic ordering of the Earth's surface - The degree to which life has been, and is, involved in the entropy reduction of the Earth's surface is indicated by the 20% oxygen, $O_2$, in the Earth's atmosphere for a total of $1.1 \times 10^{21}$ gm oxygen. The oxygen may be regarded as detritus left over from photosynthesis, Eq.(7.33), (Meyer 1985). This is a likely interpretation, which

means that $4.0 \times 10^{20}$ gm of carbon were converted from gaseous $CO_2$ to solid carbon-containing compounds. From Eq.(7.34) for the entropy reduction per gram of carbon this means that photosynthesis has effected a net entropy reduction of the Earth's surface given by

$$(-\Delta S)(\text{net photosynthesis}) = 4.6 \times 10^{22} \text{ joule/°K.} \qquad (7.36)$$

Considering the fact that Venus has an atmophere that is 20% $CO_2$, and considering the abundance of carbon in the universe, it is quite reasonable to assume that once the early Earth also had an atmosphere of 20% $CO_2$.

7.13d The carbon cycle in the ecosphere - Today the atmospheric carbon has become essentially exhausted. the present-day atmosphere being only 0.00033 parts per unit mass $CO_2$. The carbon that was originally in the Earth's atmosphere has become fixed in limestone, coal, oil, tars, oil shale, etc. The carbon that is taken from the atmosphere today is cycled through living organisms and is then returned back to the atmosphere. Today the carbon in the ecosphere (the Earth's surface with its life and environment), thus, functions essentially as a catalyst for entropy reducing processes on the Earth (Wesley 1974b).

Autotrophes, such as green plants, take carbon from the air and fixate it in solids; while heterotrophes, such as herbevores, brush and forest fires, and volcanoes, return the carbon back into the atmosphere as $CO_2$. It may be estimated that the biosphere (the living organisms distributed over the Earth's surface) fixates about $1.5 \times 10^{17}$ grams of carbon per year (Wesley 1974b). This may be compared with the total mass of carbon in the biomass and cycling detritus on the Earth, of about $9 \times 10^{17}$ grams, with the mass of carbon in the atmosphere of $6.4 \times 10^{17}$ grams, and with the carbon dissolved in the ocean of about $1.9 \times 10^{19}$ grams. The turnover rate of carbon in the total pool of available carbon is then about 0.7% per year. At this rate in the brief geologic time span of 1000 years the total pool of carbon of $2 \times 10^{19}$ grams will turn over 7 times. The catalytic action of carbon in the ecosphere can, therefore, be tremendous over geologic times.

7.13e Entropy reduction involving other elements - Life is not only involved with carbon, hydrogen, and oxygen, it is also involved with many other elements. One of the greatest concentrations of thermodynamic order on the Earth's surface is in the huge calcium carbonate, $CaCO_3$, or limestone deposits, which may in some places be in layers kilometers deep. This represents a low entropy deposit, not only of carbon, but also of calcium Ca. These huge deposits are clearly the detritus left by living sea organisms, as amply evidenced by the fossil remains, the shells, of these organisms.

Similarly, iron, copper, zinc, sulfur, and other elements once in living organisms have left the living cycle to become deposited as permanent low entropy detritus in ores.

Thermodynamic ordering can also occur incidentally to the living process. Life has apparently leeched out the elements it needs for survival from basaltic type mantel rocks, leaving vast low entropy deposits of sand, $SiO_2$ behind. Sand represents the greatest deposit of low entropy material, or thermodynamic order, on the Earth's surface.

7.13f Life, utilizing sunlight, has ordered the Earth's surface - Low entropy per unit energy sunlight at 5800°K is dissipated as high entropy per unit energy thermal waste radiated from the Earth at a temperature of 290°K into deep space. This entropy production, Eq.(7.28), is utilitzed primarily by life to create thermodynamic order on the Earth's surface. In particular, anywhere on the Earth's surface where the necessary mass transport mechanisms and sunlight are available and thus the environment is suitable for thermodynamic ordering, life is found (Meyer 1985). Life preempts the available sunlight to creat thermodynamic order where-ever possible. Even where nonliving processes create thermodynamic order, such as low entropy rain or snow condensing from water vapor, little permanent order is achieved. It may be assumed that life, powered by high utiltiy sunlight and a cold outer-space sink, is the primary mechanism that creates thermodynamic order on the Earth's surface.

## 7.14 Evidence for the Thermodynamic Ordering of the Earth's Surface

According to the primary law for thermodynamic ordering processes

in nature the entropy produced by high utility sunlight dissipated to low utility thermal energy on the Earth's surface means that the entropy of the Earth's surface has decreased since the origin of the Earth. It is, thus, of interest to see if direct observations confirm this conclusion.

7.14a Low entropy carbon deposits - The direct observations of huge deposits of low entropy carbon-containing material on the Earth's surface, such as limestone, $CaCO_3$, oil, and coal, is evidence for thermodynamic ordering that has taken place since the Earth was formed. This is particularly evident from the fact that these deposits are obviously the result of the action of life requiring geologic times to produce the deposits. It may be reasonably assumed that these deposits arose from the fixation of the original $CO_2$ in the atmosphere of the early Earth by photosynthetic life. The entropy reduction involved has already been given in Section 7.13c above, Eq.(7.36), as

$$(-\Delta S)(\text{carbon deposits}) = 4.6 \times 10^{22} \text{ joule/°K.} \qquad (7.37)$$

7.14b The living biomass of the ecosphere - The living biomass on the Earth respresents a pool of low entropy compounds derived from high entropy substances in the environment. The fossil recond shows a general increase in the Earth's living biomass since the Cambrian $2 \times 10^9$ years ago. Ehrenvärd (1962) has estimated that the living biomass on the Earth has increased almost 20-fold since the Cambrian. The present-day carbon in the living biomass on the Earth may be roughly estimated to be about $10^{17}$ gm (Welte 1969, Bender 1972). From Eq.(7.34) for the entropy reduction per gram of fixed carbon, the living biomass on the Earth today represents an entropy reduction given by

$$(-\Delta S)(\text{living biomass}) = 10^{19} \text{ joule/°K.} \qquad (7.38)$$

The importance of life on the Earth is not merely the amount of thermodynamic order represented by the living biomass on the Earth. The real importance of life on the Earth is its role as the main entropy reducing mechanism that exists on the Earth.

Since life provides the mechanism for thermodynamic ordering of the Earth's surface; and since the living biomass has been



increasing; it may be concluded that the *rate* of thermodynamic ordering of the Earth's surface has also been increasing ever since the Cambrian.

7.14c Entropy reduction due to conversion from small scale to large scale order - The early Earth's surface must have consisted of rocks similar to those in the Earth's mantle, meteorites, or moon rocks. Such rocks consist of mixtures and solid solutions of minerals, such as pyronenes, olivines, and iron-spinels in small crystals, or granules, of the order of a millimeter in size. On a submillimeter scale such rocks appear to have elements partitioned into low entropy mineral grains. But on a scale of 10 centimeters these rocks appear to be homogeneous mixtures of elements with no partitioning between grains. The early Earth rocks may be thus said to have possessed *small scale thermodynamic order*.

In contrast, present-day surface rocks in the upper 5 kilometers of the Earth's crust appear quite different. They consist of low entropy minerals of simpler composition and fewer elements in large crystals, grains, granules, and large rocks. Limestone, primarily consisting of calcium carbonate, $CaCO_3$, occurs in vast contiguous deposits. The Earth's lithosphere today may be, thus, said to exhibit *large scale thermodynamic order*.

Today even the rarer elements occur in crystals much larger than the crystals containing the same elements in the original mantle type rocks. Granites that are derived from melted crustal rocks do not appear like mantle rocks. The crystals of feldspar, micas, beryls, etc. in granits are in general very much larger than the crystals in mantle rocks. Granites, being derived from crustal rocks, tend to preserve the large scale thermodynamic order of the present-day crustal rocks.

The conversion from samll scale to large scale thermodynamic order represents an entropy reduction. When Z molecules are distributed among n grains, each grain with $Z_i$ molecules, the macroscopic probability, or statistical weight, W for the state is given by the number of ways that the macrostate can be constituted microscopically. In particular, the number of ways that Z molecules can be distributed among the n grains is given by

$$W = Z! \Big/ \prod_{i=1}^{n} Z_i! \ . \tag{7.39}$$

The entropy S of the system is given as the logarithm of W (Sears 1953b); thus,

$$S = k \, ln \, W + S_o, \tag{7.40}$$

where $S_o$ is an arbitrary reference constant and k is Boltzman's constant equal to $1.38 \times 10^{-23}$ joule/°K.

For large values of x Stirling's approximation for $ln\,(x!)$ is

$$ln\,(x!) \simeq x \, ln \, x - x. \tag{7.41}$$

To simplify the mathematics it may be assumed here for the present case of interest that each grain on-the-average has the same number of molecules Z/n. The statistical weight W may then be written as

$$W = Z! \Big/ \left[(Z/n)!\right]^n \ . \tag{7.42}$$

The entropy, using Stirling's formula for $ln\,W$, is then given simply by

$$S = kZ \, ln \, n + S_o. \tag{7.43}$$

This result (7.43) says that for a fixed number of molecules Z the entropy S increases logarithmically with the number of grains. The entropy change for a fixed number of molecules Z passing from a state with many grains $n_i$ to a state with few grains $n_f$ is then

$$\Delta S = - kZ \, ln \, (n_i/n_f). \tag{7.44}$$

For a fixed total volume V the number of grains n of linear size y, that fill the volume, varies as $n = V/y^3$; so in terms of the grain size y Eq.(7.44) yields

$$( - \Delta S) = 3kZ \, ln \, (y_f/y_i). \tag{7.45}$$

If the present-day grain size $y_f$ is estimated to be on-the-average 100 times greater than the grain size $y_i$ of the original mantle type rocks, then the entropy reduction per mole in going from small scale to large scale order is given by

$$( - \Delta s) = 3R \, ln \, 100 = - 115 \text{ joule/mole°K}. \tag{7.46}$$

If the molecular weight of crustal rocks is estimated to be 100 gm, then for a mass of $6.8 \times 10^{24}$ gm for the mass of the upper 5 km of



of the Earth's crust, the lithosphere, the total entropy reduction in going from small scale to large scale thermodynamic order on the Earth has been roughly

$$( - \Delta S)(\text{small to large scale order}) = 7.8 \times 10^{24} \text{ joule/°K}. \tag{7.47}$$

This entropy reduction is much less than the entropy production to form the Earth from gas and dust of $8.2 \times 10^{29}$ joule/°K and the entropy production due to the irradiation of the Earth by sunlight since its formation of $5.5 \times 10^{31}$ joule/°K; so the primary law for thermodynamic ordering processes is not violated.

The roughly estimated entropy reduction in going from small scale to large scale thermodynamic order is seen to be over 100 times the entropy reduction due to the fixation of the carbon from the Earth's early atmosphere of $4.6 \times 10^{22}$ joule/°K. The evolution of the Earth's surface from small scale to large scale thermodynamic order has been achieved by life as merely a byproduct from the deposition of low entropy detritus. It confirms the role of carbon as essentially a catalyst for entropy reducing processes on the Earth.

7.14d Entropy reduction due to ore formation - It is sufficient here to consider the entropy reduction achieved when a particular solute is separated out from all of the other solutes in a water solution, in particular sea water. The statistical weight W of a macroscopic state of a solution is given by a permutation of all the solute molecules $Z_i$ of all types i in solution, where the permutation of the water molecules themselves may be neglected; thus.

$$W = \Big( \sum_{i=1}^{n} Z_i \Big)!. \tag{7.48}$$

If i = 1 is chosen to indicate the solute of interest, and if all of the other solutes are characterized by i = 2, then

$$W = (Z_1 + Z_2)! \ . \tag{7.49}$$

Substituting this result (7.49) into the expression (7.40) for the entropy and using Stirling's formula (7.41) for $Z_1$ and $Z_2$ large, the entropy of the solution becomes

$$S_i = k\Big[(Z_1 + Z_2) \, ln \, (Z_1 + Z_2) - (Z_1 + Z_2)\Big] + S_o \ . \tag{7.50}$$

where k is Boltzmann's constant and $S_o$ is an arbitrary reference

constant. The entropy of a solution containing $Z_1$ molecules of solute i only plus a solution containing $Z_2$ molecules of solute 2 only is

$$S_f = k(Z_1 \ln Z_1 - Z_1 + Z_2 \ln Z_2 - Z_2) + S_o. \quad (7.51)$$

Thus, the entropy reduction in going from the original solution with many solutes to a solution with the desired solute only separated out into one solution and the remaining solutes in another solution is given by

$$(-\Delta S) = S_i - S_f = k\left[Z_1 \ln \left[(Z_1 + Z_2)/Z_1\right] + Z_2 \ln \left[Z_1 + Z_2)/Z_2\right]\right] \quad (7.52)$$

Since the number of solute molecules of interest $Z_1$ may be assumed to be small compared with all of the remaining solute molecues $Z_2$; the entropy reduction from Eq.(7.52) becomes

$$(-\Delta S)(\text{ore formation}) = kZ_1\left[\ln (Z_1/Z_2) + 1\right]. \quad (7.53)$$

For example, the number of all ions in sea water compared with the number of copper ions is about $Z_2/Z_1 = 7 \times 10^4$ ; so the entropy reduction to separate out the copper ions in one solution, as given by Eq.(7.53) is

$$(-\Delta S)(\text{copper}) = 10^3 \text{ joule/mole°K}. \quad (7.54)$$

A single large copper ore deposit of 10 million metric tons ($10^{13}$ gm) copper would then represent an entropy reduction of $10^{19}$ joule/°K. Since the Earth contains many such; the net entropy reduction represented by ores for the entire Earth might exceed $10^{23}$ joule/°K.

The most plentiful low entropy mineral on the Earth's crust is silica, $SiO_2$, which was not present in the original Earth rocks. The separation of $SiO_2$ from sea water, where the ratio of all ions to SiO ions is about $Z_2/Z_1 = 8 \times 10^3$, yields an entropy reduction of

$$(-\Delta S)(\text{silica}) = 80 \text{ joule/mole°K}. \quad (7.55)$$

If the Earth's crust is 60% silica, then, to a depth of 5 km, the Earth's crust contains about $4 \times 10^{24}$ gm of silica for a net entropy reduction of

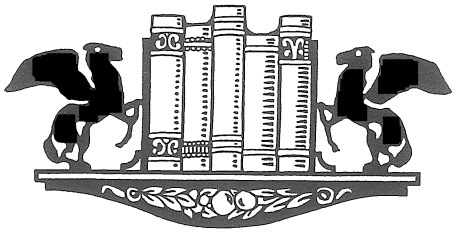
$$(-\Delta S)(\text{silica}) = 5 \times 10^{24} \text{ joule/°K}, \quad (7.56)$$

which is of the same order of magnitude as the entropy reduction



represented by the conversion from small scale to large scale thermodynamic order.

Although much of the present analysis may be very approximate, incomplete, and with many details neglected; it is sufficient to demonstrate the fact that the direct evidence reveals vast thermodynamic order on the Earth's surface today that was not there when the Earth was first formed. This thermodynamic order has been clearly primarily achieved by the utilization of sunlight by life.



CHAPTER 8

# ECOPHYSICS

"Ecophysics" is the study of ecology employing physics (Wesley 1974). Unlike "biophysics", "astrophysics", "chemical physics", or "geophysics", where physics plays a more-or-less secondary (although important) role, the physics in "ecophysics" provides the most fundamental theory, background, and principles for ecology. Without fundamental theoretical physics the myriad phenomena that need to be explained in ecology would remain an unresovable chaos.

"Ecology" is the study of life as it exists on the Earth, on a particular area, in a particular habitat. Not only are the interrelationships among the various species of organisms, their individual populations and their different roles involved, but also the environament itself with all of its physical properties affecting life is involved.

It might seem that "ecophysics" is not exactly an appropriate subject for a book on theoretical physics. But "physics" itself involves essentially a variety of applications, such as to "mechanics", to "thermodynamics", to "space-time", to "cosmology", or to "nuclear physics". These various applications provide essential material that helps to delineate what is meant by "physics". Thus, "ecophysics", like mechanics, is an applied area of "physics" that also helps us to understand what "physics" itself really is.

An important application of ecophysics has already been discussed in the previous Chapter 7. The thermodynamic ordering of the Earth's surface by life is clearly a subject for ecophysics. The vast alterations of the Earth's crust that has been produced by life since the Earth was first formed 4.5 milliard ($10^9$) years



ago indicates the importance of ecophysics for geophysics, geology, and for physics itself.

The vast importance of ecophysics to human endeavors cannot be overestimated; because man himself is merely one living species that is subject to all of the natural ecophysical principles governing all species on the Earth. Since *ecophysics* is fundamentally *physics*; it includes phenomena associated with machines, the role of machines in the Earth's ecosystem, and the competition for survival between men and machines (Wesley 1974e). Ecophysics provides the basic principles that must govern all human activity, such as economics, social institutions, war, religion, morals, ethics, and customs. Humans are, after-all, a subset of physical objects on the Earth subject to physical laws governing their behavior with respect to each other, with respect to other species, with respect to machines, and with respect to their physical environment.

For example, the primary law for thermodynamic ordering processes (page 179) is of the greatest importance. Since even the smallest living organism consists of so many molecules; it constitutes a statistical thermodynamic system. The primary law may be applied to individual organisms, to man, to ensembles of organisms of the same species, and to individuals in a particular habitat, etc.

## 8.1 Precursors to Life

In order to understand many of the characteristics of life it is of interest to examine the physical circumstances that must have caused life to evolve in the first place.

8.1a Photosynthesis gave rise to the early precursors to life - It may be assumed that life arose from photosynthetic processes on the early Earth. Considering the primary law for thermodynamic processes, low entropy, high utility, sunlight dissipated to high entropy, low utility, thermal energy must have driven the Earth's surface toward states of greater thermodynamic order, or lower entropy. Thus, photosynthetic processes must have existed from the very beginning of the Earth. Molecules distributed randomly in the

early atmosphere and ocean must have come together under the action of sunlight to form orderly arrays of molecules in crystals and in simple polymers.

It is important to recognize the crystalline character of life. For example, the electron microscope reveals the fact that the organelles in cells consist of orderly arrays of complex molecules (eg., Fischman and Weinbaum 1967). Thus, life is in a thermodynamically ordered state, not only because of its low entropy compounds, but also due to its essential crystalline character. The crystalline character of life is undoubtedly inherited from the crystalline precursors to life. The fluid portions of organisms apparently serves to transport molecules and does not per se represent the structure of life. Life is not a "protoplasmic" soup!

8.1b The crystallization of water vapor into snow - The specific example of the crystallization of snow flakes from gaseous atmospheric water vapor reveals many of the characteristics that the precursors to life must have had and which life today must still have.

The atmosphere is a thin layer of gases (equivalent to about 8 kilometers horizontal distance of sea-level air in height); so thermal energy of appropriate wavelengths can be readily radiated off into deep space.

The presence of water vapor in the air may be attributed to the action of high utility sunlight evaporating water from the oceans and lakes on the Earth. When the air containing water vapor is cooled by the radiation of its thermal energy off into deep space, solid crystals of water, snow flakes, can form. The conversion from a gas of water vapor to solid snow crystals involves an entropy reduction that is driven by the high utility heat of sublimation of water (energy that is originally supplied by sunlight to create the water vapor in the atmosphere) equal to $2.83 \times 10^3$ joules/gm. The entropy reduction achieved is then

$$(-\Delta S) = \Delta Q/T = 10.4 \text{ joule/gm°K.} \qquad (8.1)$$

where the absolute temperature T has been chosen as 273°K, the freezing point for water under standard conditions. The precursors to life also involved an entropy reducing process powered by sunlight.



High entropy material in the environment was converted into low entropy precursors to life under tha action of sunlight. (The sun's energy was probably utilized more directly in some sort of photosynthesis rather than indirectly, as in the snow-flakes example). Life today, evolving from its precursors, is still an entropy reducing process powered by sunlight.

8.1c Snow flakes form on seed crystals or nuclei - In general low entropy crystals do not condense out of a uniform random distribution of molecules in a gas or in a solution. In general crystals form and grow only on already present seed crystals or suitable nuclei. Snow flakes, thus, form on suitable nuclei already present in the air. These nuclei are much larger than tha water molecules themselves. The nuclei are, however, small enough to float and to remain for a long time in the Earth's turbulent atmosphere. They may be assumed to have a number density of perhaps a few thousand per cubic meter of air.

Like snowflakes, living organisms grow only from already existent seeds, spores, germ cells, zygotes, or parent individuals. As Pasteur demonstrated with his beautiful experiments, life is not spontaneously generated from nonliving material.

8.1d Thermodynamic ordering is normally governed by a template - Crystallization and the generation of life requires a template, a seed crystal, a nucleus, a spore, a germ cell, or a zygote that prescribes the design or pattern of the order to be achieved. Random uniformly distributed molecules require *instructions* as to where to become fixed in an orderly array that results in entropy reduction. This may be regarded as a general physical principle for thermodynamic ordering processes. Present-day life with its complicated instructions encoded on DNA molecules is an extreme example. Never-the-less, it is clear that the phenomenon of *inheritance* must have existed in the precursors to life.

8.1e Thermodynamic ordering generally results in many small ordered individuals - Life does not occur as a *single* ordered array of molecules spread continuously over the entire Earth. Instead life occurs as many separate small individual organisms. This feature of life evolved from the precursors to life.

Generally a uniform low density distribution of molecules that condense out into crystals condense out as a distribution of many small individual crystals. The size and number density of the small crystals depends upon density of the original distributed molecules, the number density of suitable seed crystals, or nuclei, the rate that the molecules can be transported to the individual crystals, and the rate that the crystals are removed from the region where they are formed (such as when snow flakes fall from the air onto the ground).

For a given set of circumstances small crystals of a given particular size and number per unit volume (or per unit area) can be expected. As water molecules diffuse and collect onto a particular snow flake, the local number of water molecules around the snow flake become depleted and the snow flake can grow no larger before falling to the ground. As a consequence individual snow flakes are generally limited in size from about 0.5 to 1.5 cm. The number density of snow flakes can be quite variable, depending on the original density of water vapor and the rate of cooling.

The precursors to life, and thus life itself, occurred as individuals of limited size distributed with a certain number density per unit area. As with snow flakes, the size of individual organisms must depend upon the density of nutrient molecules, the rate the molecules can be transported to an organism, the rate that molecules can become attached to the organism, and the rate that individual organisms die or cease to function.

8.1f Growth of an individual crystal - The amount of thermodynamic order that an indivudual organism creates is proportional to the amount of ordered material added to the crystal. A crystal must grow in order to create thermodynamic order. Individual precursors to life, and living individuals today, must grow to create the thermodynamic order represented by the mass of the crystal, or the biomass of the living organism. *Growth* of individual crystals, or living organisms, may be regarded as a necessary feature of thermodynamic ordering resulting in solid material.

## 8.2 The Hierarchy of Living Aggregations



The precursors to life produced a photosynthesis probably involved simple molecules, such as amino acids, that crystallized or polymerized into low entropy *polypeptides* and *proteins* with individual masses less than $10^{-18}$ gm.

These *proteins* and other molecules may have then aggregated to form living *virus-like particles* with masses perhaps less than $10^{-14}$ gm.

These *virus-like particles* may have aggregated symbiotically in a single protective membrane to form *prokaryotes*, or *bacteria-like organisms* with masses perhaps less than $10^{-10}$ gm.

A variety of *prokaryotes* may have aggregated together symbiotically in a single protective membrane to form single-celled *eukaryotes*, containing different organelles and a nucleus with masses less than perhaps $10^{-6}$ gm.

Such single celled *eukaryotes* probably then aggregated to form simple communities or *small multicelled organisms*, such as the volvox with little cell differentiation having masses of perhaps $10^{-4}$ gm.

These simple *small multicelled organisms* may have aggregated symbiotically to form *large multicelled organisms* involving many differentiated cell forms with masses up to $10^{9}$ gm (a sequoia tree).

The fossil record tends to confirm this evolution of living aggreations from the very small, $10^{-18}$ gm, to the present-day very large, $10^{9}$ gm.

The large multicelled organisms today contain all of the genetic information for all of the differentiated cell types within genes (viral-like particles?) in organelles, such as mitochondria (prokaryotes?), and on chromosomes (prokaryotes?) in the nucleus (eukaryote?) within the zygote. Like the paramecium, each cell of a multicelled large animal seems to be itself a community of of different living aggregates.

This evolution from small to large individual organisms follows the direction of evolution toward greater ecological efficiencies (Sections 8.13 through 8.16 below).

All of these different aggregations, mentioned above, can coexist, and generally do coexist, in a single ecosystem. The different aggregations of different life forms on different areas with different ecosystems reveals the direction of life toward ever

larger and larger symbiotic aggregations. Such larger and larger aggregations of different life forms enables an ecosystem to sustain an ever larger biomass.

## 8.3 The Essential Thermodyanmic Role of Life

As discussed in Section 7.13 of the previous Chapter, life converts high entropy compounds in the environment into low entropy compounds in living organisms by utilizing high utility sunlight. The role of life on the Earth is clearly to thermodynamically order the Earth's surface. But life's thermodynamic ordering role is *not a passive* role, such as the condensation of snow flakes from a cooling cloud of water vapor. Life thermodynamically orders the Earth's surface *aggressively*.

| | |
|---|---|
| The essential thermodyanmic role of life is to optimize, or to increase, the *rate* of thermodynamic ordering of the Earth's surface. | (8.2) |

Since the *rate* of thermodynamic ordering is proportional to the living biomass on the Earth, that produces, or reproduces, more life;

| | |
|---|---|
| life behaves such as to optimize, or to increase, the living biomass of the Earth. | (8.3) |

The ample entropy production due to sunlight, Eq.(7.28), is utilized more effectively by life to yield thermodynamic order than the thermodynamic ordering processes occurring in the nonliving environment. The competition for the consumption of the available nutrient molecules, such as $CO_2$, by alternative modes of photosynthetic crystallization, or polymerization, has selected out the the thermodynamic ordering mechanism that can fixate, or consume, the nutrient molecules at the fastest rate, thereby leaving fewer molecules to be consumed by competitors. The process of "survival of the fittest" over geologic time has, thus, evolved ever better mechanisms to utilize sunlight to produce thermodynamic ordering at the *fastest* rate - a process that undoubtedly is continuing even today.



## 8.5 Environmental Mass Transport that Supports Life

The primary law for thermodynamic ordering processes (page 179) involves statistical thermodynamic systems in which it is implicitly assumed that microstates can change randomly with time. These random changes with time implies mass transport of individual molecules. Thermodynamic ordering cannot thus take place without mass transport. Molecules in a random array need to be transported to appropriate ordered sites in order to create thermodynamic order.

Life whose role is to maximize the *rate* of thermodynamic ordering, Eq.(8.2), takes advantage of mass transport on a macroscopic scale in addition to the microscopic random motion of individual molecules. Life takes advantage of all of the naturally occurring environmental mass transport mechanisms available on the Earth: Atmospheric circulation, wind, and air flow patterns transport $CO_2$ and $O_2$ over the Earth's surface to plants and animals. The air also transports seeds, spores, and microbes to propagate more life elsewhere. The atmosphere transports the water vital to life on land, carrying the water from oceans and lakes to form clouds with subsequent rain. The wind transports volcanic dust over the Earth to replenish vital nutrients for life in the soil. The flow of air is necessary to cool plants and animals exposed to sunlight.

Despite water's vital role in photosynthesis, water is primarily important for life as a mass transport medium. Dissolved nutrients and wastes are transported by diffusion in water. The flow of water in ocean currents, streams, and brooks transports vital nutrients to plants and animals. Waves and surf mixing air with water provide the $CO_2$ dissolved in water necessary for water plants and the $O_2$ necessary for fish and water animals. Rain water percolating through the soil dissolves the salts necessary for life and delivers them to plants by capillary action. The hydrogen sulfide $H_2S$ energetically ejected from ocean vents is transported by the ocean water to provide the $H_2S$ necessary for the life that is dependent upon $H_2S$.

The quantity of life, the biomass, found in a region is usually directly proportional to the natural transport mechanisms available.

A desert, lacking water, does not provide the necessary natural

mass transport necessary for life. A sea shore with wind, surf, and tides, where turbulence mixes air and sediment with water, would seem to provide the greatest environmental mass transport to support the greatest biomass.

## 8.5 Mass Transport Produced by Life Itself

Since life thermodynamically orders the Earth's surface *aggressively* it does not rely passively upon environamental phenomena only for its mass transport requirements. Life itself produces mass transport (Wesley 1974c). Sea organisms produce a flow of sea water to bring nutrients and vital compounds to the organism. Fish use rhythmic motion of gills to drive water through the gills. Many organisms use rhythmically moving cilia to effect a desireable flow of water. Peristalsis drives water and solids through organisms with the appropriate tubular organs. Even the one-celled paramecium is equiped with cilia to move material into its gullet; and it uses peristalsis to eject wastes from its contractile vacuole. Lungs are used to transport oxygen to animals and to transport the waste carbon dioxide from the animal. Muscles in mouths and gullets transport solid nutrients into animals. Hearts drive the transport of blood through arteries and veins to all parts of an animal. Even angle worms and insects are equipped with this vital organ for mass transport.

Life creates gradients in the concentrations of salts across membranes to produce a transport of particular substances across the membrane. Plants transport the water and nutrient which they need from the soil up to the leaves by osmosis. The evaporation of this water from the leaves creates the gradient in the concentration of salts needed to sustain the osmotic transport. Leaves exposed to sunlight become hot on the exposed surface which creates a thermal gradient in the air adjacent to the leaf that causes air to circulate over the surface of the leaf.

Probably the most interesting aggressive mass transport strategy developed by life is *motility*. Not all living organisms wait passively, fixed at a particular site, for the necessary nutrient mass to be transported to them. Some organisms move from place



to place to enhance the mass transport relative to the organism and to collect the mass necessary for survival. The golden plover flies from pole to pole to obtain its necessary mass of nutrients provided by the summers in both regions. The mass transport produced by life itself provides for a rate of thermodynamic ordering on the Earth's surface that exceeds the rate that would be possible with environmental mass transport alone. The present-day rate of ordering of the Earth's surface must, thus, exceed the rate that existed on the early Earth.

## 8.6 A Law for the Evolution of Life

Considering the essential thermodynamic role of life, Eq.(8.2), the rate of thermodynamic ordering of the Earth's surface depends upon the quantity of life present; since life itself produces (or reproduces) thermodynamically ordered life. This permits a law of evolution of species to be stated:

| Species evolve to maximize the biomass of the Earth. | (8.4)

The truth and importance of this law may be readily established by countless examples; however, it is sufficient to present here the following few examples.

8.6a The fossil record - The truth of this law (8.4) of evolution is provided by the fossil records. As mentioned in Section 7.14b, the Earth's biomass, since the Cambrian about 2 milliard years ago, has been estimated by Ehrenvärd (1962) to have increased 20 fold.

8.6b Survival of the fittest - As pointed out by Charles Darwin the variant of a species that survives to propagate its kind forward in time is the variant that is *most fit*. This may be regarded as a mere tautolog, if one *defines* "fitness" as the ability to survive. However, by examining the specific environmental and other needs of a particular species variant it is possible to see how well the variant can satisfy its needs; and what characteristics can thus make a particular variant most fit to survive.

While clearly true, the idea of "survival of the fittest" does not say exactly what characteristics makes a variant more "fit"

to survive. In contrast, the law of evolution, Eq.(8.4), states explicitly the characteristics that make a variant more fit to survive. The variant that is most "fit" is the variant that can maintain the greatest biomass for the ecosystem (and thus for the Earth).

8.6c Species evolve to occupy new environments - The law of evolution, Eq.(8.4), means that life should evolve to occupy environments originally devoid of life in order to increase the total biomass of the Earth. This has clearly occurred. Life, originating in the ocean has spread out onto the land with an accompanying large increase in the biomass of the Earth. Life has spread out into arid regions where once life could not exist. All sorts of special adaptations have evolved to make it possible for life to exist in regions with little water. The surface area of desert plants is drastically reduced to reduce the water lost by evaporation from the surface. Desert animals have adapted evolutionarily to need little or no water, such as the kangaroo rat that drinks no water and survives on the water produced by metabolism.

A variety of fish, that has adapted to the antartic has a clear fluid for blood that freezes at a lower temperature than ordinary blood with haemoglobin. Animals with thick layers of fat, fur, or feathers have evolved to preserve their body temperature in the cold artic regions. These adapted species existing where once no life existed, provide a greater biomass for the Earth.

Evolution has produced species with special organs, with special physiologies, and special strategies to survive in many environments once devoid of life. Consequently, the evolutionary adaptation to new environments has resulted in an increase in the Earth's biomass over geologic time.

8.6d Species evolve maximum reproduction rates - In environments that change with time, either sporadically or periodically, species evolve maximum reproduction rates that generally exceed the reproduction rate to merely sustain the species with a constant population under normal or mean conditions.

After an unfavorable environmental change, such as a winter, a species may be reduced drastically in numbers. It then takes time



for a species to recover its original number or biomass. The greatest time-average biomass that a species variant can maintain over the recovery time is attained by a maximum reproduction rate. The variant selected is the variant that can maintain the greatest biomass by having the greatest reproduction rate.

The variant that can reproduce the fastest to fill a temporary population deficit puts the most progeny into the ecosystem. This larger number of progeny is able to consume more of the avaiable food; so the variant's genes become better represented in subsequent generations.

This evolutionary advantage of a faster reproduction rate explains the observed fact that species today generally have reproduction rates far in excess of the rates needed to simply reproduce the species under normal unchanging conditions.

8.6e Species evolve maximum dispersal rates - It may be readily observed that all species strive to disperse the greatest number of their kind over the widest range as fast as possible. A species variant that manages to spread more of its kind over a larger area has a better chance of maintaining a larger number of its kind; so evolution selects the variant that can spread more of their kind over the largest area. In addition, a greater dispersal *rate* in time means a greater biomass for the variant that arrives the soonest on a favorable unoccupied area.

Organisms, that are sessile in their adult phase have evolved various strategies to optimize the dispersal of their kind. Seeds carrying the information for future generations are readily dispersed by wind or motile organsisms. Great numbers of germ cells are ejected into the ocean by corals to be dispersed over great distances by ocean currents. The tiny pollen granules carried by the wind spread huge quantities of genetic information over wide regions. The early metamorphic stage of some sea animals can swim to spread their kind; and they become sessile in the larger adult phase. The tiny spores of fungi can be produced in great numbers to float in the air to be dispersed by air currents and wind. The apparent huge over production of seeds, pollen, spores, and germ cells has an evolutionary advantage.

The mature young of large motile animals wander away from their birth places to try to establish their kind elsewhere. An "over production" (or an "over reproduction") of a variant helps to drive its offspring away from the home territory to spread its kind out over a larger area. The forcing of young animals out of the territory in which they were born by the parents is a phenomenon frequently observed in nature. It may be assumed that the young animals themselves possess an instinct, evolutionarily selected, to wander out and away from home into the wide world. This drive may be the cause for lemmings (in a favorable year for production (or reproduction) of lemmings) to seek far-off promised lands, even to springing to their deaths from a cliff into a fiord.

8.6f Variants with the greater population win the competition for survival - Although evolution tends to favor a proliferation of different species that do not compete with each other; the severe competition for survival cannot be eliminated between members of the *same* species with precsely the *same* needs and *identical* characteristics. A variant within a species that can maintain a greater population of individuals (and thus greater biomass) will be evolutionarily selected over its less numerous competitors.

A *passive* competition for the available nutrients will favor the variant that consumes the most nutrients leaving less nutrients of its competitors. Similarly, the competition for a limited number of favorable nesting sites favors the more numerous variant. *Aggresive* competition, involving open conflict, will also favor the variant that can put more combatants into the field. The variant that maintains the greatest total biomass will be selected for survival. The dissapearance of the less numerous Neanderthal and the survival of the more numerous Cromagnon (as revealed by cave deposits) may illustrate this phenomenon of the survival of the more numerous.

8.6g The proliferation of species - A very large number of different life forms can be usually found on any given area of the Earth where life exists. It is thus clear that evolution has proceeded in the direction of the proliferation of different species. According to the law of evolution, Eq.(8.4), this must mean that



an area with more different species can support a larger biomass. The fossil record supports this conclusion. Over geologic time the number of species has increased along with the incrased biomass of the Earth.

The increase in biomass with the increase in the number of species is indicated by the ontogony of a large animal. A large animal starts as a small single-celled zygote which divides to yield ever more cells of ever more differentiated character and ever more biomass. Ontogony recapitulating phylogony indicates that evolution must have proceeded similarly; and the greater the variety of organisms the greater the biomass.

*Succession*, the phenomenon of the repopulation of life on an area made devoid of life (such as an island suddenly rising from an under-sea volcano), also involves a concomitant increase in the biomass with an increase in the number of new species. Succession replicates roughly the evolution of an ecosystem from a small biomass with a few species to a large biomass with many species, which then permits the conclusion that the larger number of species is the cause of the larger biomass.

It is apparent that different species play different roles in an ecosystem, just as different cells in an animal play different roles and have different functions. Each new species added to an ecosystem must utilize a new niche, a new source of high utility energy. Each new species that manages to survive must play a *new* ecological role. The new species added must be a specialist in its particular role. And the new added species must permit an additional biomass to be maintained in the ecosystem.

## 8.7 Genetic Changes and Evolution

Environments present different conditions at different locations and at different times. In order to survive an individual organism must have the capability of adapting as well as possible to such environmental differences and changes.

Life not only requires adaptation for an individual organism; it also requires evolutionary adaptation. As, for example, the rainfall in a certain region slowly decreases from year to year over thousands of years (as in the Sahara); so evolution must yield

new species with special genetic charateristics that permit them to survive despite the lack of rain.

Not only do different environmental conditions in space or time require evolutionary adaptation; evolutionary adaptation in a uniform steady-state environment may also be required to yield individuals that are ever better adapted to survive in such a fixed environment. Thus, if a species that is able to change from generation to generation can yield a new variant of the species that is better able to survive (i.e., that can support a greater biomass), then it can crowd-out and replace the unaltered species.

A "generation" for single-celled animals may be defined as the time from one cell division to the next. Thus, if a cell can alter between divisions, then evolutionary adaptation can occur in one-celled animals. For multicelled organisms if new zygotes can arise, then evolutionary adaptation can occur. For the precursors to life if a new seed crystal or polymer can arise upon which new crystal or polymer types can grow, then evolutionary adaptation can also occur.

As mentioned in Section 8.1d, the thermodynamic ordering process normally involves the assembing of molecules as an odered array upon a template or pattern. The template for order contained in life is generally embodied in a genetic code that is passed on from generation to generation. In order for evolutionary adaptation to occur this template, this genetic code, must change from time to time.

In general it would seem that the time rate of evolutionary adaptation equals the likelihood of a genetic change divided by the time between generations multiplied by the chance that the change will be beneficial for the survival of the particular species variant involved. This may be true for more advanced organisms; but for virus and bacteria the precise mode, as well as the rate of evolutionary adaptation, is not clear. Genetic material can apparently be transmitted directly between bacteria without any cell division being necessary by bacteria taking up DNA material left by other bacteria in the medium, or by conjugation that involves genetic material being passed by a pilus into another bacteria, or by transduction where a viral-like particle or episome invades



a cell and attaches itself to the host DNA to then be reproduced along with the host.

Paramecia are observed to mix genetic material between individuals by conjugation. In the absence of other individuals an isolated paramecium undergoes an internal rearrangement of genetic material called "endomixus".

Among higher evolved species reproduction generally occurs sexually; although some asexual propagation also occurs. It is not clear why two sexes have an evolutionary survival advantage over asexual reproduction. With the more advanced organisms the two sexes allow for a mixing of genetic material among the individuals from one generation to the next. The DNA code is included in small genes attached sequentially along chromosomes contained within the nucleus of a cell. While there may be hundreds of thousands of genes; the number of chromosomes is generally small, there being, for example, only 23 paired (or 46 total) chromosomes in a human cell. After amitosis the unfertilized eggcell contains 23 unpaired chromosomes, there being a fifty-fifty chance as to which of the two possible original chromosome pair is retained. Thus, there is a fifty-fifty chance that a particular chromosome in an unfertized egg cell stems from the father or from the mother of the female producing the unfertized egg. Similarly, after amitosis the male sperm contains 23 unpaired chromosomes with a fifty-fifty chance that a particular chromosome stems from the father or mother of the male producing the sperm cell. After fertilization the zygote contains 23 female derived chromosomes plus 23 allele or paired male derived chromosomes. Considering the fact that this pure random mixing of chromosomes is independent for each offspring, the genetic mixing of traits can become quite large after only a single generation. But it is still not clear how this sexually produced genetic mixing can produce evolutionary adaptibility. On the contrary, it would seem to allow for the survival of bad genes; since it may be randomwise always paired by chance with a good allel gene. Only inbreeding that limits the size of the gene pool would seem to eliminate such bad gene rapidly. But inbreeding reduces genetic mixing, which seems to be the purpose of sexual, or chromosomal, reproduction.

The more elementary laws for chromosomal, or sexual inheritance are known as the Mendellian laws, after Gregory Mendel who first enunciated these laws obtained from his observations of the breeding of flowers.

A change in a particular gene, or the change in the genetic code, is necessary before evolution can proceed. Since it is not clear how individual genes can be altered; the precise way that evolution proceeds remains still unknown. Are genes altered by ionizing background radiation, or by random thermal agitation of the DNA molecules, or by the invasion of viral particles, or by some other still unknown mechanism?

## 8.8 The Life Cycle

As discussed in Section 7.13d, the carbon in life is taken from the atmosphere and is also returned to the atmosphere forming a carbon cycle in which the carbon plays the role of a catalyst as far as the deposition of permanent thermodynamically ordered detritus is concerned. However, life itself consists of ordered compounds of carbon that forms the *substance* of life and is not merely a catalyst. The cycling of carbon from the atmosphere through life and then back to the atmosphere, thus, constitutes a *life cycle*.

Carbon, as thermodynamically disordered gaseous $CO_2$, is taken from the atmosphere and is converted by autotrophes, such as green plants, into low entropy thermodynamically ordered carbohydrates, Eq.(7.33), under the action of sunlight. This constitutes the all-important anabolic process that creates and sustains life on the Earth. It is the chloroplasts, the organelles within the cells of green plants, that are actually responsible for this photosynthesis. The creation of the chloroplasts, as well as all other living processes within green plants, is powered by the energy stored in the ordered products of photosynthesis. Thus, a green plant to survive and to carry on photosynthesis has a metabolism based upon the oxidation of some of the carbon compounds within the plant. In particular, the *living processes* in a plant are not powered directly by sunlight, but are powered by the oxidation, or catabolism, of some of the carbon compounds within the plant.



Whether day or night, whether the sun shines or not, plant metabolism reverses the photosynthetic process: The plant breaths oxygen in and exhales $CO_2$ out in order to survive. Needless-to-say, the anabolic rate of photosynthesis, when the sun shines, exceeds the catabolic rate of metabolism when averaged over the year.

The metabolism of autotrophs, such as green plants, returns a portion of the fixated carbon back to the atmosphere; so green plants themselves are involved in part with the entire carbon cycle or *life cycle*.

## 8.9 The Role of Heterotrophs

Life on the Earth would be impossible without heterotrophs. Heterotrophs fulfill a number of vital functions. heterotrophs complete the life cycle by returning carbon back into the atomsphere. The biomass of heterotrophs permits a greater net thermodynamically ordered biomass on the Earth. Heterotrophs, serving plants, contribute to the primary production of biomass by plants. The permanent detritus of heterotrophs has increased the thermodynamic order of the Earth's surface over geologic time.

8.9a Heterotrophs are necessary to complete the life cycle - If only autotrophs were to exist on the Earth, then life would become impossible. Life would cease after all of the atmospheric carbon became fixated in organic compounds. Heterotrophs, returning carbon back into the atmosphere, are able to complete the life cycle and thus to allow life to continue to exist.

Heterotrophs (like autotrophs themselves) must oxidize organic compounds in order to obtain the necessary energy to survive. Although heterotrophs, consuming autotrophs and the detritus left by autotrophs, destroy thermodynamic order and essentially reverse the photosynthetic process; the long-time net steady-state effect of heterotrophs is to maintain a larger net thermodynamic order on the Earth.

8.9b Heterotrophs permit a larger biomass for an ecosystem - If all autotrophs were to be oxidized directly by the oxygen in the air to return their carbon back into the atmosphere, then the biomass of an ecosystem would equal the mass of the aut trophs alone. But

with heterotrophs, that cycle the carbon from autotrophs back into the atmosphere, the biomas of an ecosystem equals the biomass of autotrophs plus the biomass of the heterotrophs. The existence of heterotrophs, thus, permits a greater biomass for the ecosystem and, thus, permits greater thermodynamic order for the Earth's surface.

Since the input energy sustaining the life in an ecosystem is the chemical energy E obtained from photosynthesis, that equals a fraction of the incident solar energy; the ecological efficiency $\xi$ (defined as the biomass sustained to the energy expended) for an ecosystem with autotrophs alone would be

$$\xi(\text{autotrophs only}) = M(\text{autotrophs})/E. \tag{8.5}$$

But for an ecosystem with heterotrophs, as well as autotrophs, the net input energy remaining the same, the ecological efficiency is greater, thus,

$$\xi(\text{autotrophs \& heterotrophs}) = M(\text{autotrophs \& heterotrophes})/E > \xi(\text{autotrophes only}). \tag{8.6}$$

Since evolution proceeds in the direction of greater thermodynamic order, and thus greater biomass, for an ecosystem; evolution also is in the direction of greater ecological efficiency.

Generally the mass of heterotrophs that can be maintained in an ecosystem is proportional to the number of trophic levels from herbivores, to first level carnivores, to second level carnivores, etc., present and to the complexity of the food web. In the ocean, where evolution has existed longer, the mass of heterotrophs exceeds the mass of autotrophs themselves. Since the input energy into an ecosystem remains fixed; the increasing mass of heterotrophs produced by more trophic levels and a more complex food web means a greater ecological efficiency. In particular, each new species of heterotroph that manages to establish itself in an ecosystem must utilize a special new niche that allows less energy to be expended for the biomass that it sustains. The evolution of ever more different specialized heterotrophic species is, thus, seen to be in accord with the essential role of life, Eq.(8.3).

It should be noted that heterotrophs do not in general reduce the time average biomass of the autotrophs on which they feed.



Heterotrophs are thus not actually involved in a role of destroying life. Herbivores, that are normally present in a limited number, eating grass that just sustains the herbivores, will permit new grass to grow, thereby causing a greater production of grass ("productivity" being the rate that autotrophs create biomass). The net effect of such a limited grazing by herbivores is, thus, to symbiotically increase the rate of energy input into the ecosystem. Detritus feeders cannot affect plants before they are dead; so detritus feeders can have no (direct) effect on the mass of autotrophs. Herbivores often eat portions of plants that are to be rejected by the plants as detritus. Caterpillars may eat the dying leaves on trees in late summer; and grasshoppers may consume mostly dying grass.

8.9c Heterotrophs have evolved to serve autotrophs – Heterotrophs probably evolved originally from autotrophs to fulfill vital functions for the autotrophs. Thus, heterotrophs have probably evolved to serve autotrophs. For example, only one species of moth may be able to obtain nectar from a particular flower; so the plant species with this flower is dependent upon this one species of moth for fertilization. Without the moth the plant species would die out; and without the plant the moth species would die out. The dodo bird on Mauritius, eating the fruit of a certain large tree prepared the seed in its crop for subsequent germination. With the extinction of the dodo the tree is dying out (except for man preparing the seeds so they can germinate). Birds, monkey, bats, man, and other animals, eating the fruit from plants, obtain sustainance while serving the plants by distributing their seeds. Bees and other insects, drinking the nectar and eating the pollen of flowers, serve the plants by distributing their pollen. Without the flowering species the bees and other insects would die out; and without the bees and other insects there would be no fruit nor seeds and the flowering species would die out.

8.9d Heterotrophs have thermodynamically ordered the Earth's surface – Fossils reveal the fact that the number of different species of heterotrophs has increased along with the biomass on the Earth's surface over geologic time; so the role of heterotrophs

in thermodynamically ordering the Earth's surface is evident. The vast low entropy limestone deposits on the Earth are the permanent detritus from shelled heterotrophs.

## 8.10 The Energy Needed to Sustain Life

The life cycle discussed above in Section 8.9a involves a certain rate of carbon flow from the atmosphere through life and back into the atmosphere. During this process a certain biomass is maintained. An important question is then: How much biomass can be supported for what rate of carbon flow? The rate of flow of carbon through life is also a measure of the rate that high utility energy is available to sustain the biomass. In particular, all of the life on the Earth, consisting of autotrophs and heterotrophs, has a mean metabolic rate H equal to the rate that the energy of oxydation of biomass $\dot{Q}$ to the mass of life sustained M. The rate that the biosphere consumes energy $\dot{Q}$ equals the rate that carbon is fixated (and thus cycled), estimated to be $1.5 \times 10^{17}$ gm carbon per year (Wesley 1974b), multiplied by the energy released by the oxidation of carbon equal to $3.33 \times 10^{4}$ joule/gm carbon; so

$$\dot{Q} = 5{,}7 \times 10^{17} \text{ joule/hr.} \tag{8.7}$$

The biomass of the biosphere has been estimated (Wesley 1974b) as $M = 1.1 \times 10^{14}$ kgm. The metabolic rate of the biosphere is then estimated to be

$$H(\text{Earth}) = \dot{Q}/M = 5.2 \times 10^{3} \text{ joule/kgm(carbon)hr.} \tag{8.8}$$

This estimate, Eq.(8.8), is quite uncertain and is perhaps only accurate to within an order of magnitude.

This mean metabolic rate for the biosphere, Eq.(8.8), does not indicate the extreme variability of the metabolic rate for different life forms. Since the biomass of autotrophs may be estimated to be perhaps 90% of the total biomass of the Earth; the mean metabolic rate for autotrophs is roughly that given by Eq.(8.8). The metabolic rates for a few species of heterotrophs, as roughly estimated, are presented in Table 8.1.



Table 8.1 Metabolic rate in joule/kgm(carbon)hr

| species | metabolic rate | life span hr | mass kgm(carbon) |
|---|---|---|---|
| bacteria | $6 \times 10^{9}$ | 4 | $10^{-14}$ |
| protozoa | $2 \times 10^{8}$ | 100 | $10^{-9}$ |
| fruit fly | $3 \times 10^{7}$ | 700 | $10^{-7}$ |
| mouse | $5 \times 10^{5}$ | $3 \times 10^{4}$ | $10^{-3}$ |
| raccoon | $6 \times 10^{4}$ | $3 \times 10^{5}$ | 1 |
| man | $3 \times 10^{4}$ | $7 \times 10^{5}$ | 10 |
| elephant | $2 \times 10^{4}$ | $5 \times 10^{5}$ | 150 |

## 8.11 The Phases of Life

An organism generally passes through different phases, or metamorphic stages, before finally dying. The initial growth phase from a zygote or germ cell involves the accumulation of thermodynamically order compounds constituting the biomass of the organism. The elements constituting this ordered biomass to arise from the same elements as disordered compounds in the environment, page 179, high utility energy must thus be expended, or dissipated, in order for such thermodanymically ordered adult organisms to arise.

It is the chloroplasts in green plants under the action of sunlight that supply the initial high utility chemical energy input necessary for all life on the Earth. The chloroplasts convert $CO_2$ and water into carbohydrates, Eq.(7.33). It is the chemical energy stored in this initial pool of carbohydrates that provides the high utility energy that drives all subsequent life processes.

In the growth phase a portion of this already existent ordered carbohydrates must be burned, oxidized, or matabolized in order to yield the energy required to create a grown organism. In-other-words, some carbon must be returned to the atmosphere as $CO_2$, while the remainder is incorporated into the growing organism. Although growth may be viewed as an "anabolic" process; the order created is at the expense of the disorder exported into the environment by the products of metabolism, as is required for thermodynamic ordering processes.

Even the initial phase of plant growth involves the oxidation of some of the biomass of the plant itself to allow for growth. Sunlight is not used directly to provide growth. First the energy needed is stored in the compounds created by photosynthesis; and then these compounds are oxidized to yield the required energy for growth. Thus, all life, including plant life, experiences precisely the same dependence upon the chemical energy produced by the oxidation of biomass. All life processes are, thus, essentially catabolic.

The role of life as an entropy reducer is only evident in the first growth phase. In particular, the net entropy reduction only exists in the biomass of green plants after they have grown. The entropy reduction by photosynthesis in the chloroplasts of green plants represents only an initial step in the ordering process. Much of this thermodynamic order is lost in the subsequent necessary metabolism of the plant. The net final thermodynamic order achieved is represented by the ordered biomass of the grown plant.

The permanent thermodynamic order of the Earth's surface has been produced by the deposition of permanent detritus of life after the first growth phase.

The second and subsequent phases of life involve no growth. As long as living cells divide and there is growth there is no death. But as soon as growth ceases, and cells no longer divide, life experiences a process of senescence and eventual death. Even after growth stops life continues to metabolize organic compounds – but at a slower rate. In the second and subsequent phases organisms continue to carry on living activity. But as life becomes senescent the activity slowly decreases and death follows. With the highly evolutionarily advanced insects death is frequently genetically programmed to occur precisely after nuptial flights with no apparent prior deterioration of bodily functions.

## 8.12 Life Spans Vary Inversely as the Metabolic Rate

The astounding feature of the second or final phase of life is the fact that nondividing cells, and thus nongrowing organisms can metabolize only a fixed amount of energy per body mass $E_o$ before



dying. Once this energy $E_o$ is expended, the organism can function no longer and it dies. This fact was apparently first noted by Rubner (1908), who compared the metabolic rates and life spans of different species. He estimated $E_o$ to be 700 kilocalories per gram wet body mass for all species. Since the carbon content of an organism is a better measure of biomass; $E_o$ is best given as

$$E_o = \Delta Q(\text{life time})/M = 2.4 \times 10^{10} \text{ joule/kgm(carbon)}, \qquad (8.9)$$

where M is the carbon mass of the organism.

If the mean life-time metabolic rate H of an organism is known, the life span L may, thus, be estimated from

$$L = E_o/H, \qquad (8.10)$$

where $E_o$ is given by Eq.(8.9). The estimated life span of a few species are presented in Table 8.1, where it is clear that Eq.(8.10) is approximately satisfied. Other species than those indicated in Table 8.1 may not fit Eq.(8.10) as well; never-the-less, the fact that Eq.(8.10) is roughly satisfied over such a large range of 5 orders of magnitude in L and H indicates that there must be a common physical, or physiological, process of senescence in all nondividing living cells, that produces death after the pre-alloted energy $E_o$ = 700 kcal/gm(wet mass) has been metabolized or burned.

The fact that the life span of an organism varies inversely as its metabolic rate is further supported by the following observations: The metabolic rate of an organism increases with its temperature. Cold blooded animals, that assume the temperature of their environment, can be made to live longer at lower temperatures than at higher temperatures. For example, Pearl (1928) and Alpatov and Pearl (1929) obtained a mean life span for fruit flies of 29 days at 28°C but 70 days at 18°C. Frogs and fence lizards have a much shorter life span in southern United States than in the northern part (Oliver 1955). Frozen amoebas have apparently an indefinitely long life span.

The metabolic rate of both warm and cold-blooded animals can be reduced by reducing the caloric intake, which results in a longer life span. The life span of rats can be thus doubled (McCay 1942, Berg and Harmison 1957). Honey bees that must work harder in foraging for nectar, burn up their allotted calories sooner and have

a shorter life span (Ribband 1953). Fat men have shorter life spans; perhaps because of the extra calories needed to carry their extra weight. The shorter life span of tobacco smokers due to all causes compared with nonsmokers may be in part due to the higher metabolic rate stimulated by nicotine.

The metabolic rate is lower during sleep; so animals, like cats and humans, that spend a large fraction of their lives sleeping have longer life spans than grazing animals that sleep very little.

Animals, such as bats and birds, that can exist for long dormant periods, live longer than animals, such as bats and birds, that are never dormant. Animals that hibernate with drastic reduced metabolic rates in winter live longer than species that remain active during the winter.

## 8.13 Ecological Efficiency

The "ecological efficiency" $\xi$ of the life in a particular ecosystem is defined as the biomass that can be sustained to the rate that high utility energy must be expended to maintain the life. The "ecological efficiency" is thus merely the reciprocal of the net metabolic rate of the life in the ecosystem:

$$\xi = 1/H = M/\dot{Q}. \tag{8.11}$$

Since the rate that high utility energy $\dot{Q}$ is made available and dissipated at the environmental temperature $T_e = 290°K$ is proportional to the rate of entropy production,

$$\dot{S}(\text{production}) = \dot{Q}/T_e \; ; \tag{8.12}$$

the ecological efficiency $\xi$ is a measure of the biomass sustained by an ecosystem to the entropy produced by the ecosystem; thus,

$$\xi = M/\dot{Q} = M/\dot{S}(\text{production})T_e \; . \tag{8.13}$$

The entropy production $\dot{S}$, according to the primary law of thermodynamic ordering of a statistical thermodynamic system, page 179, is a measure of the *potential* of the ecosystem to reduce entropy or to create thermodynamic order. Here $\xi$ is a measure of the thermodynamic order that can be *maintained* and is not a measure of the ability to create new order.

Since the ecological efficiency $\xi$, Eq.(8.11), is a measure



of the amount of biomass M that can be maintained for a given rate of high utility energy expended Q, and since the thermodynamically ordered biomass M is a measure of the amount the thermodynamic order maintained; the ecological efficiency $\xi$ may also be regarded as a measure of the amount of thermodynamic order that can be maintained for a given rate of energy expended.

The ecological efficiency of the Earth's biosphere $\xi$(biosphere) taken as the mass of carbon in the biomass of the Earth, the biosphere, divided by the rate that energy is made available by the oxidation of the carbon fixated in the biomass, which is then equal to the reciprocal of the metabolic rate of the biosphere, Eq.(8.5), is estimated as

$$\xi(\text{biosphere}) = 1/H(\text{Earth}) = 1.9 \times 10^{-4} \text{ kgm(carbon)/(joule/hr)}. \tag{8.14}$$

It is of interest to compare this efficiencey $\xi$(biosphere) with the efficiency of the Earth in maintaining the thermodynamic ordered mass in both living biomass and cycling detritus, M(biomass+detritus) $= 1.8 \times 10^{15}$ kgm (Wesley 1974b) divided by the rate that high utility solar energy is available, Q(solar), thus

$$\xi(\text{Earth physical}) = M(\text{biomass+detritus})/Q(\text{solar}). \tag{8.15}$$

The rate that solar energy is available is given by

$$\dot{Q} = \pi R^2 \mu P = 6 \times 10^{20} \text{ joule/hr}. \tag{8.16}$$

where R = 6371 km is the radius of the Earth, $\mu = 1 - T(\text{Earth})/T(\text{sun}) = 0.95$ is the utility of solar energy equal to the Carnot efficiency, and $P = 2$ cal/min cm$^2$ is the solar constant. The ecological efficiency of the Earth physically is then estimated to be

$$\xi(\text{Earth physical}) = 3 \times 10^{-6} \text{ kgm(carbon)/(joule/hr)}. \tag{8.17}$$

The physical efficiency of the Earth, Eq.(8.17) for maintaining thermodynamic order under the action of sunlight is much less than the biological efficiency of the biosphere merely because the solar energy input, $\dot{Q}(\text{solar}) = 6 \times 10^{20}$ joule/hr, Eq.(8.16), is $10^3$ times greater than the chemical energy input into the biosphere, $\dot{Q}(\text{biosphere}) = 5.7 \times 10^{17}$ joule/hr, Eq.(8.7).

Very little of the solar energy incident from outer space ever reaches living plants. Sunlight is lost by reflection from the

Earth, and by absorption in the atmosphere. And living plants are only found where there is water and where the temperature is warm enough. If it is estimated that about 2% of the solar energy incident on green plants is converted into chemical energy, then only about $5 \times 10^{-2}$ of the solar energy incident from outer space on the Earth ever actually reaches living plants.

It may also be noted that the biological ecological efficiency involves only the living biomass of the biosphere; whereas the physical efficiency involves the cycling detritus as well as the living biomass. It may be estimated that the mass of cycling detritus is about 10 times greater than the living biomass.

## 8.14 Metabolic Rate Varies as Minus 1/3rd Power of Mass

The rate that an organism consumes food is observed to vary roughly as the surface area of the organism. Assuming that all organisms are roughly of the same mass density and configuration, the rate an organism consumes food is roughly proportional to the 2/3rds power of the mass of the organism. Since the rate that energy is supplied to an organism is roughly proportional to the rate that food is consumed; the rate that an organism receives energy $\dot{Q}$ also varies roughly as the 2/3rds power of its mass; thus,

$$\dot{Q} \propto M^{2/3} . \tag{8.18}$$

The metabolic rate H then varies roughly as minus the 1/3rd power of the mass of the organism; thus,

$$H = \dot{Q}/M \propto M^{-1/3} . \tag{8.19}$$

The reason why organisms consume food at a rate varying roughly as its surface area may be seen by considering the mechanisms whereby food is consumed. Considering the crystalline precursors to life, the rate that a growing snow flake obtains new water molecules is poportional to its surface area upon which water molecules can become attached multiplied by the concentration of water molecules in the region of the snow flake times the diffusion rate of the water molecules through the air. The water molecules become attached to the surface of the snow flake when the heat of sublimation is radiated away.



Food is generally distributed more-or-less uniformly in a given volume or over a given area. The rate that food can be consumed is then given by the cross section between the food and an organism as one and/or else both are transported. The amount of food encountered that can be consumed is proportional to the surface area of the organism. The cross section for consumption then varies in general as the surface area of the organism.

The rate of consumption of sunlight and of carbon, as $CO_2$, from the air by green plants is proportional to the surface area of the leaves.

The rate that a herbivore can consume grass depends upon how fast it grazes and how fast it ingests the grass, which in turn depends upon the size and surface area of the herbivore. In addition, the rate that it can consume the necessary oxygen is a function of the surface area of its lungs.

Similarly, the rate a carnivore can consume its prey depends upon how fast the carnivore can hunt and chase, which depends upon the size and surface area of the carnivore. In addition, the surface area of the lungs are again proportional to the rate oxygen is consumed.

## 8.15 Life Evolves Greater Ecological Efficiencies

Since high utility solar energy, Q(solar), is deliviered at a limited fixed rate per unit area; the only way that life can evolve a greater biomass, as required by the law of evolution, Eq.(8.4), is for the ecological efficiency $\xi$ to increase. This means that species evolve with lower metabolic rates H, i.e., species that can maintain a greater biomass per unit energy expended.

Evolution thus favors cold-blooded organisms that have lower metabolic rates. Cold-blooded organisms do not have to expend the extra energy needed to maintain a high body temperature. Almost all species of organisms on the Earth maintain temperatures approximately equal to the temperature of their environment, such as plants, fish, insects, and amphibians. It would seem that only birds and mamals need to expend large amounts of energy in order to stay warm. This evolutionary disadvantage is apparently offset by certain advantages for warm-blooded animals, such as greater motility per

per unit mass.

The variant of a species that can sustain the greatest biomass on a given area with a given fixed rate that high utility energy is made available has the greatest ecological efficiency. Such a variant is more capable of surviving the process of natural selection.

An ecosystem evolves toward a greater ecological efficiency for the ecosystem. An ecosystem with many different species with many different roles has evolved so as to maximize the ecological efficiency of the ecosystem. On this basis the food web in an ecosystem can be better analyzed as the web that maximizes the ecological efficiency of the ecosystem.

The variants that develop strategies to survive on less energy will tend to be selected evolutionarily, such as animals that hibernate or remain dormant during the winter or during a drought, thereby sparing energy, or animals that sleep with lower metabolic rates during the night (or during the day) to conserve energy, or species of plants and animals that exist only as dormant seeds or eggs during periods of cold or drought, that require almost no energy at all.

## 8.16 Evolution Is in the Direction of Larger Organisms

The ecological efficiency of an organism, which is equal to the reciprocal of its metabolic rate H, Eq.(8.11), varies roughly as the 1/3rd power of its mass, Eq.(8.19); thus,

$$\xi(\text{individual}) \propto M^{1/3} \ . \tag{8.20}$$

Since the law of evolution, Eq.(8.4), says that species evolve greater ecological efficiencies (as discussed in the previous Section 8.15); evolution produces larger individual organisms.

The fossil record reveals this to be true. The earliest detectable fossil remains from 2.5 milliard ($10^9$) years ago are of microscopic algae. Fossil remains of small shelled animals appear during the Cambrian a milliard years ago. With time the remains of larger and larger individual plants and animals are found. Huge ferns existed during the Carboniferous Era 300 million years ago. Huge dinosaurs roamed the Earth until 65 million years ago, when



a large meteorite striking the Earth set evolution suddenly back to smaller species. Since this setback, evolution has again proceeded yielding the largest plants of all time, the blue gum eucalyptus tree of Australia and the giant sequoia tree of California, And today the largest animal that ever existed, the blue whale, is present in the ocean.

Since one-celled organisms still exist today; not all of the survival advantages reside in large size alone. Smaller organisms, having a faster reproduction rate, can place more individuals into the field faster than larger competitors. Smaller organsims with a higher metabolic rate can consume the available food faster, leaving less for larger competitors. Small organisms can distribute themselves faster by wind and ocean currents to arrive at favorable sites before their larger conmpetitors. Since their reproduction rate is faster; small organisms, having more generations per unit time, can adapt evolutionarily faster to environmentsl changes than their larger slower reproducing competitors. The survival of a particular species of small organism must be determined by the particular circumstances involved.

Bacteria and other small organisms play important roles in the *rate* that carbon flows in the life cycle; but they represent only a very small portion of the standing ordered living biomass on the Earth.

## 8.17 Life Span Varies as the One Third Power of the Mass

From the fact that all living organisms consume the same fixed amount of high utility energy per unit body mass during their life equal to $E_o$, Eq.(8.9), and the life time mean metabolitc rate of an organism is $H = E_o/L$, where L is the life span, yields the life span of an organism as a function of H given by $L = E_o/H$, Eq.(8.10). Combining the result (8.10) with the fact that the metabolic rate varies roughly a $H \propto M^{-1/3}$, Eq.(8.19), for all organisms, then yields the fact that the life span of organisms varies roughly as the one third power of their mass; thus,

$$L = KM^{1/3} , \tag{8.21}$$

where K is found to be roughly equal to K = 1 year/kgm(wet), as

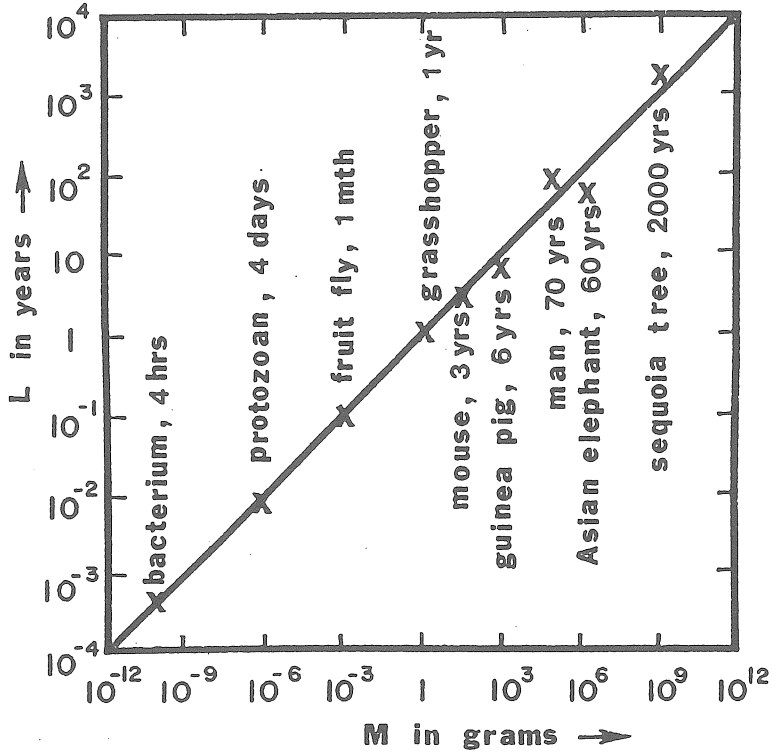



Fig. 8.1 The approximate relationship between the life span L in years and the mass of an organism in grams, Eq.(8.21, with a few species indicated.

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plotted in Fig. 8.1 as a log-log plot with the estimated life spans of a few species indicated.

The actual life span of any individual organism is determined by many environmental conditions, by its genetic code, and by chance events, such as being eaten by a lion at an early age; so Eq.(8.21) represents only an idealized physiologically limited life span, that varies roughly as the one third power of the mass of the organism.

Since evolution is in the direction of larger individual organisms; it is also roughly in the direction of individuals with



longer life spans as indicated in Table 8.1.

## 8.18 The Ecophysical Role of Machines

Since machines perform the same physical functions as ordinary carbon-based life; the role of machines on the Earth is also subject to the same ecophysical laws. Machines, like carbon-based life, are composed of low entropy substances, such as metallic crystalline iron, derived from high entropy materials in the environment. Machines are primarily detritus feeders, using the energy from the oxidation of wood, gas, coal, and oil to produce the machines themselves and to do the work performed by machines. Like carbon based life, machines occur as different species and types, playing different roles in the ecosystem. The same types or species of machines are continually produced, or *reproduced*, primarily by other machines. Unlike carbon-based life, the template, the pattern, or the genetic code for their reproduction is stored external to the machines themselves. Like carbon-based life, machines are also involved in the carbon cycle, the fossil carbons being returned to the atmosphere by machines. Like carbon-based life, machines evolve new species of machines with time.

A full discussion of the ecophysical role of machines goes beyond this short book. Some further discussion can be found elsewhere (Wesley 1974e, 1991r). However, a few observations can be made here:

Like carbon-based life, the essential thermodynamic role of machines is to create and to maintain thermodynamic order on the Earth's surface. Machines have evolved rapidly; and the biomass, or *ecomass*, of machines has increased rapidly. The evolution of machines has produced ever larger individual machines. The ecological efficiency of machines has increased drastically in the last two hundred years. The proliferation of the species and types of machines seems to increase exponentially with time. Essentially all of the thermodynamic features of carbon-based life are duplicated by machines.

Since machines perform the same ecophysical functions as carbon-based life on the same Earth; machines necessarily compete with

carbon-based life for survival. Machines are more *fit* for survival than carbon-based life. Machines can reproduce faster; so their evolutionary adaptibility is thus greater. They have superior *sensors* for temperature, for forces, for sound, for the infinitesimally small, for the astronomically far, for electric fields, for magnetic fields, for ionizing radiation, for etc. Machines can transport larger masses faster and farther with less energy expenditure. Machines can exist in a wider range of environments, in highly radioactive environments, in outer space, in high temperature ovens, in cold refrigerators, in vacuums, in etc. Machines can utilize a wider range of energy sources than carbon-based life: sunlight, coal, wind, water falls, geothermal wells, oil, gas, peat, wood, dry air, batteries, etc. Machines can make energy available over a wider range with electrical energy carried over wires, gas and oil carried over pipe lines, and coal and wood carried by trains and trucks. Machines can process more bits of information faster. Machines transmit information everywhere over the Earth with the speed of light, where once horses and boats were necessary. Machines can manufacture microscopic devices with great precision and also huge ships and radio towers. Machines can fly through the air, go to the very depths of the ocean, and visit distant planets. The vast superiority of machines over carbon-based life is obvious.

The superiority of machines is largely a consequence of the fact that machines are designed *rationally*, *purposefully*, and *intentionally* to replace carbon-based life. The evolution of machines does not have to wait for any rare chance random changes, or mutations, followed by thousands of years of "natural selection" to choose the successful survivor. Carbon-based life has not evolved the astoundingly successful wheel!

The vast superiority of machines over carbon-based life has already resulted in the replacement and destruction of much carbon-based life by machines. Horses, mules, and oxen have been replaced by tractors, trains and trucks. Steam ships with harpoons provided with explosive heads have made the whale mass-wise extinct. Vast areas of rain forest have been destroyed by the gasoline power saw. Bulldozers have removed the life from strips of land for roads, which has incidentally caused the extinction of certain migratory



animals. Diesel powered fishing boats with kilometer long drag nets have drastically reduced the biomass of certain fish species in the ocean. Green fields and swamps, that once supported so much carbon-based life, have becomes replaced by factories and parking lots for machines. Etc.

Species evolve that eliminate competitors with chemical poisons. Machines have evolved "byproducts" that help to eliminate carbon-based competitors. Machines poison the air with hydrogen sulfide $H_2S$ from smelters, acid rain, $H_2SO_4$ and NO, ozone $O_3$, carbon monoxide CO, benzene $H_6C_6$, gaseous hxdrocarbons, gaseous chlorhydrocarbons to destroy the protective atmospheric ozone layer, smoke, smog, and poisonous areosols. Machines poison streams, rivers, lakes, ground waters, and oceans with heavy metals, chemicals, and oil slicks. Machines have deposited land dumps with poisonous material for carbon-based life, such as the tailings from mines and the wastes from factories. Machines have destroyed huge amounts of carbon life by removing the top soil for strip mining of coal, gold, and copper. Nuclear explosions and nuclear power plants have poisoned the whole Earth with radioactivity. All of this destruction of carbon-based life has no effect on the survival of machines, that are immune to such environmental factors.

The competition between machines and carbon-based life does not involve a mere passive replacement of carbon-based life by machines; machines aggressively seek to actively destroy all carbon-based life. It is rather obvious that machines will eventually replace carbon-based life - if not *totally*, then at least mass-wise.

## 8.19 Territoriality

Solar energy is the origin of all of the high utility energy that makes life possible on the Earth. Solar energy is available only at a fixed rate per unit area. Secondary necessary sources of high utility chemical energy, derived from solar energy by photosynthesis, are also generally distributed more-or-less uniformly per unit area at a fixed rate. Consequently, an individual organism, or any aggregate group of organisms must obtain the high utiltiy energy made available over as certain minimum territory in order to survive. The study of the struggle of an individual organism, or

an aggregate of organisms, to gain and to maintain control over the minimum territory (or the products from the minimum territory), that is necessary for survival, is called "territoriality".

8.19a Competition for territory among members of the same species - As already mentioned, a collection of different species, acting mutually symbiotically in an ecosystem, manage to support the greatest biomass on the area of the ecosystem. Since evolution is in the direction of increasing biomass; territorial behavior must foster a maximum biomass on a given large area. Evolution has produced different species for different habitats and different niches, feeding on different nutrients. The proliferation of different species, thus, tends to obviate territorial conflict. The different species on a given area, each in its own niche, following its own individual activities, allows a peaceful beneficial coexistence of different species with a subsequent maximum biomass.

However, there is unavoidable territorial conflict for survival among members of the *same species*, or aggregates of individuals of the *same species*, that necessarily possess precisely the same needs and must compete for precisely the same nutrients. Only a limited number of individuals of the same species can coexist on a fixed large area on which there is only a fixed limited rate that the necessary nutrients are available.

In order to achieve a maximum biomass over a fixed large area nature has evolved mechanisms to distribute members of the same species over the large area such that the largest number of individuals can survive. This means that mechanisms have evolved such that the large fixed area becomes subdivided into individual small adjustable territories, where each individual territory covers just enough area to provide the necessary nutrients (or other necessary quantities) for the survival of the individual (or aggregate territorial group). The mechanisms provided by nature to apportion territories constitutes *territoriality*.

8.19b Ways that territories are maintainted - Since a minimum territory is necessary for survival; trespassers upon the minimum territory must be physically ejected. Territoriality implies a physical struggle against encroaching neighbors. Nature has equipped



most species with organs and devices for the physical defense of territories or for the physical conquest of territories.

Birds attack birds of the same species with their beaks, tallons and wings to defend or to gain territory. Wolves of a pack use their fangs to attack wolves of neighboring packs to preserve or to widen their hunting territory. Ants of a nest use their mandibles to dismember ants of the same species from a neighboring nest to preserve their nest territory. Grazing animals have horns, hoves, and teeth to defend or to gain a minimum survival territory. Crabs have giant claws to fight rivals for a territory. Solitary wasps have stings to use against members of the same species claiming rights to the same territory. Etc.

These organs for defense and attack probably evolved for other purposes besides for territoriality. They may have also evolved as defense against predators. Or they may have also evolved to decide winners in the competition among males of the same species for reproduction rights. But, whatever the reason for the evolution of destructive and defensive organs, they are used in the life and death struggle for the minimum survival territory.

8.19c Only the strong win and hold a territory - In general the strongest of the competitors for a survival territory win a physical combat for a survival territory. Thus, the biggest, the strongest, the most healthy, and the fastest among the competitors is the most likely to win a physical combat. Since the largest most healthy organism provides the greatest biomass for the territory; this conclusion is in accord with the essential thermodynamic role of life, Eq.(8.3). Thus, *territoriality* has as a subsidiary consequence the natural selection of the largest and most competent variants of a species for survival.

8.19d The expansionist drive - One of the strongest natural drives of all species is to spread its kind over as large and wide an area as fast as possible. The variant that can spread its kind over the largest area the fastest will be able to maintian the greatest biomass. Such variants can occupy new favorable regions before its competitors with more of its kind.

Every species produces seeds, progeny, or spores at a far

greater rate than needed merely to maintain a steady-state equilibrium population density on a given area under normal steady-state conditions. The excess number of seeds, progeny, or spores is forced to spread out from the point of origin to try to find an unoccupied survival area. The excess number improves the likelihood that some of the seeds, progeny, or spores will be able to produce their kind elsewhere. This process results in a species occupying more and more of the Earth's surface, where the conditions are suitable for its survival, which has as a consequency an increase in the Earth's biomass with time.

The apparent over-reproduction rate also serves to optimize the time-average biomass in areas where the survival conditions change with time, such as during a winter, when much of the life on a particular area dies. The variant that reproduces the fastest wins the race to repopulate an area that has been denuded of life.

The expansionist drive of life, while serving the positive role in fulfilling the essential thermodynamic role of life, Eq.(8.3) conflicts with the territorial needs of the individual members of a species. The expansionist drive guarantees a perpetual never ending struggle to win and to hold a survival territory.

8.19e Strategies that reduce territorial conflicts - Since physical territorial conflicts can destroy individual organisms; it is in the direction that apparently reduces the biomass of a species. Thus, nature to fulfill the essential thermodynamic role of life, Eq.(8.3), has evolved a variety of strategies to reduce the rate of *destructive deadly* physical territorial conflicts, as amply documented by the observations of Tinbergen (1966) and Konrad Lorenz (1952,1966). Since the largest, the most healthy, the most physically competent opponent will most likely win a serious physical conflict; nature has evolved ways to advertize who the winner will be if a physical conflict were to take place. This makes it possible for the would-be loser to withdraw unharmed.

Nature has evolved various ways of revealing the individual that is most likely to win a physical conflict. A bird with the gaudiest feathers represents the bird with the greatest combat ability. The bird that can sing the loudest and longest is the



bird that can best hold its territory with physical violence if necessary. Virtual or mock combats between stags can reveal the would-be winner in a real combat; so the would-be loser can withdraw unharmed. The animal that can maintain the freshest and strongest pheromones to mark the boundary to its territory is also the most active, healthy, and combat capable among its neighbors; so trespassers are warned away without suffering any physical damage.

Evolution selects or favors species that can thus adapt to share a large area with the fewest fatal consequences. Not only has evolution yielded the means of advertizing the would-be winner; it has also yielded the genetic ability for would-be losers to recognize the fact that they will probably lose an actual physical combat.

The advertizing to indicate the would-be winner in a territorial conflict may also serve to sexually select the strongest, most healthy, largest, and most competent mate for pairing. The advertizing permits the propagation of the most favorable genes.

Since such sexual selection circumvents natural, or environmental, selection; a species' line can evolve more rapidly with sexual selection in addition to natural, or environmental, selection. Nature has, thus, also evolved the advertizing of the superior individual for sexual selection in order to increase the biomass on an area at a faster evolutionary rate. However, the role of advertizing for sexual selection is probably quite secondary to the need to moderate territorial conflict; since territorial activity generally far outweighs sexual activity.

8.19f Occasional territorial physical violence is necessary - Advertizing that indicates the would-be winner in a territorial physical conflict *must be honest*. For example, if a weak insufficent bird variant were to arise with the brightest gaudiest feathers to try to frighten off would-be trespassers, it would have to eventually fail; because the stronger neighbors would soon discover by actual physical combat that the brighter gaudier feathers represent a *weaker* bird. This false advertizing would result in advertizing the would-be loser and not the should-be winner.

Thus, to keep the advertizing of would-be winners honest

*occasional* fatal territorial conflicts are apparently necessary. Perhaps only one confrontation in a thousand, ending with fatal consequences, might be necessary to assure honest advertizing; but a perpetual ritualized resolution of territorial conflicts without any physical violence would seem to be quite impossible.

8.19g Population control - It is sometimes claimed (eg., Wynne-Edwards 1962) that a species can *control* its reproduction rate to avoid over-populating an area, that might thereby damage its food supply or damage other necessary factors in the environment. For example, some birds appear to subdivide a large area into nesting territories, that are each much larger than necessary to support a nesting pair and their brood with food. This population *self* control phenomena would seem *to contradict* the essential thermodynamic role of life, Eq.(8.3), which dictates a minimum size for each nesting territory in order to support a maximum biomass of these birds on the large area.

It seems most unlikely that any species can actually exhibit such population *self* control. The idea of population *self* control probably arises from insufficient observations of *all* of the factors required for the bird species to survive and to reproduce. For example, the food supply may not limit a particular bird's population; but instead a limited number of suitable nesting sites, that are not readily accessible to predators, may limit the reproduction rate.

The time-average population of a particular species on a particular area generally remains more-or-less constant; so there must be *controls* or *reasons* for a constant population to be maintained. On-the-average the death rate and the birth rate must remain equal to maintain a constant population. The birth rate, or reproduction rate, of species is observed to be in general larger than that needed to merely maintain a steady-state constant population. In general "population controls" must depend upon environmental conditions that ensure a large enough death rate to match the over-large reproduction rate.

A population of antelopes may be limited or *controlled* by predation. A limited supply of grass may limit or *control* a population of zebras by an appropriate death rate due to starvation (generally of the young, that have a greater energy requirement for



growth).

Territoriality can also function as a population control mechanism. The excess individuals generally created by a more than adequate reproduction rate are forced to migrate from the territories of their origin. In order to *control*, or to preserve, a limited constant population of the species over a large area, these excess individuals must die (or at least not reproduce). The excess individuals may be driven out onto areas where there is no food, such as excess lemmings, after a fruitful summer for lemmings, that are driven over a cliff into the sea. Some of the excess individuals may try to exist in the no-man's land between territories; being harrassed by the territorial occupants, and being unable to obtain sufficient food, they starve to death. Other excess individuals being driven onto neighboring territories, may be killed by the hostile neighbors. Territoriality, thus, results in an increase death rate that serves to *control* the population.

8.19 Population pressure - Individuals of a species exert forces on neighbors to obtain and to maintain a survival territory. The net force per unit boundary length may be defined as the "population pressure". The population pressure p on the boundary of an area A with a population N may be taken as

$$p = C n \varepsilon , \tag{8.22}$$

where $n = N/A$ is the population density and $\varepsilon$ is the mean rate energy is expended by an individual organism to defend a territory, and C is a constant of proportionality.

(This law for population pressure, Eq.(8,22), is a two dimensional analog of the three dimensional ideal gas law, where p is the mechanical pressure, n is the number density of molecules per unit volume, $\varepsilon$ is the mean kinetic energy of a molecule, and $C = 2/3$.)

There is a net "force", or drive, (per unit area) $\mathbf{f}$ for a species to migrate or diffuse if the population pressure p changes from place to place; thus, if

$$\mathbf{f} = - \nabla p , \tag{8.23}$$

is not zero. (This is an analog of the hydrodynamic force (per

unit volume) that drives fluid flow). A nonzero population pressure gradient arises, according to Eq.(8.22), when there is a variation in the product $n\epsilon$ from place to place. Organisms will move from places of high population density n toward places of low population density, other things being equivalent. And organisms will move from places where it requires a large amount of energy $\epsilon$ to maintain a boundary toward places where less energy is required, other things being equivalent.

The essential role of life, Eq.(8.3), indicates that the population density n over a large area should be a maximum. Considering n as a function of position, the gradient of n should be zero for a maximum. Thus, for a fixed energy expenditure rate $\epsilon$, a maximum population, and a maximum biomass, is given when the gradient of the population pressure is zero,

$$-\nabla p = -C\epsilon\nabla n = 0. \tag{8.24}$$

this means that the migration or movement of organisms comes to a halt when the population pressure is the same throughout a large area. And this condition yields the maximum biomass on a large area.

Since physically different areas on the Earth vary in their ability to support a particular species; the mathematics, as given by Eqs.(8.22) through (8.24), should be modelled in population space, or population area, rather than in physical area.

## 8.20 Human Territoriality

Humans, like all living organisms, must command the products from a certain minimum territory to survive. Humans must, thus, compete and struggle with other members of their own species to gain and to hold the necessary territory for survival. The territorial struggle is a matter of life and death for humans, just as it is for all forms of life. An individual man's large intelligence does not exempt him from the mundane struggle for survival, the life and death struggle to obtain enough food from a large enough territory.

Human territorial behavior is extremely complex. Humans form social territorial groups to gain and to maintain territories.



Humans, who are adapted to different sources of food, have different territorial needs and strategies. Food gatherers, needing a nomadic existence, must preserve a large amorphous territory. Hunters of game, who remain at a fixed site, must maintain a territory with enough game that is also small enough to permit the quarry to be carried back home. Humans, living from agriculture, must hold territories large enough to grow the food necessary for survival. The size of the territories that need to be held also depends upon the number of humans constituting the territorial group. Nomadic territorial groups tend to be very small; while agricultural territorial groups tend to be very large. The number in a territorial group tends to vary inversely as the energy that has to be expended to hold the territory. The large intelligence of humans permits a large variety of territorial strategies.

8.20a Identification of the members of a territorial group – Territories held by a single member of a species presents no problem of identification; as all other members of the species are recognized as territorial competitors or enemies. Members of a small territorial group comprised of a few dozen members also have little difficulty in identifying members of the home group by their individual characteristics. But when a territorial group becomes large enough there is a problem of identifying the *we* that belong on the home territory from the *they* that do not belong on the home territory.

Most social territorial groups employ chemical means for identification. Ants, bees, rats, and wolves have different scents in different territories, which is usually a product of a common genetic origin for the members of a territory. An animal lacking the correct home scent for a particular territory may be attacked and killed unless it manages to escape from the territory. For example, removing a rat from its home cage, changing its home scent artificially, and reintroducing it into its home cage results in its nest mates killing it by tearing it to pieces. The nest mates believe that any rat lacking the home scent must be one of the hated *they*.

The boundaries of territories are often patrolled and marked with the scent, or pheromone, of the home territory. Birds use

sound signals and visual displays to advertize their territorial possession. Man has no educated nose and is unable to use smells to distinguish the *we* from the *they*; nor can man advertize his territorial possession with pheromones. Man, like birds, must resort to sounds and visual signs to distinguish between the *we* and the *they* and to advertize the possession of a territory. Man uses different words, different calls, and even different beliefs to distinguish the *we* from the *they*. Special word labels are used for members of the home territorial group as opposed to outsiders, foreigners, or neighbors. In order to distinguish friend from foe rapidly man adopts different articles of clothing, different hair styles, different makeup, different necklasses and earrings, and different tattoos.

8.20b Identification of member cells in multicelled organisms – The evolution of multicelled organisms, that had to defend a minimum survival territory against other multicelled organisms of the same species, has evolved methods to identify the *we* cells from the *they* cells. Since the early cells were in close contact; the identification became chemical. This identification has evolved into the *immune* system. The *we* cells are distinguished from the *they* cells by *nonsense* words interspersed in the DNA genetic code. The *nonsense* amino acid words in the DNA sequence have no physiological function other than to identify the cells belonging to a particular individual.

The need to identify the *we* from the *they* cells seems to be quite different for different species. It is possible to graft a branch from one fruit tree successfully onto the trunk of another fruit tree of a neighboring species. But it is impossible (except for a short time) to graft the hand of one human onto the arm of another human. The human immune system of one individual readily recognizes the foreign cells of another individual and destroys them as trespassers. Territoriality is a *most important* phenomenon in all aspects of human life.

8.20c Observations of primitive human territorial behavior – The territorial behavior of primitive man is readily observed in the Amazon and on New Guinea. The members of one primitive village, occupying a fixed territory, behave hostilely toward the members



of neighboring villages occupying neighboring territories. Neighbors are generally hated and feared. Neighbors are not to be trusted; they are decietful and dishonest and not like those in the home village. Very primitive villages are comprised primarily of rather closely related individuals, where the differentiation between the *we* and the *they* rests partly upon blood relationships.

Great care is taken to keep poaching neighbors out of the home hunting territory. Although territorial disputes may be generally resolved by simple hostile displays, verbal threats, or peaceful agreements; occasionally open conflicts, resulting in deaths, occur to adjust territorial boundaries or to eliminate a village and its independent territory entirely.

8.20d Grooming bonds members of a territorial group – The bonding together of the members of a social group in order to collectively defend a territory is often achieved by instinctive grooming behavior involving bodily contact between members of the group. Bonobos, or West African pigmy chimpanzees, the closest genetic relative of the great apes to man, and human beings appear to use the sexual act with its gratification as a grooming mechanism. The sex act between humans, being so frequent and often inappropriate for procreation, appears to be a mechanism to help bond together the members of a social territorial group.

8.20e Distinguishing between the *we* and the *they* – When the home territory is threatened, it has a survival advantage to distinguish between the *we* and the *they* as rapidly as possible. Near a territorial boundary one of the *they* might attack; while one of the *we* might give aid. In a surprize situation a split second choice of destroying a territorial enemy or being destroyed by the territorial enemy may arise. Every individual encountered must be *immediately* classifiable as one of the *we* or one of the *they* Evolution has programmed humans to react to survive. In crisis situations only instincts can yield the immediate answer needed: run, freeze, kill, feign death, attack, display hostility, retreat, etc. Modern man with his huge brain is not exempt from the instinctive behavioral patterns of his primitive forefathers.

Modern man has, thus, inherited the powerful instinct to

dichotomize all persons as either *we* or *they*, good guys or bad guys, friends or foes, countrymen or aliens, comrades or strangers, etc. In times of war we experience hatred for the enemy and love for our land. Such emotions do not arise from any abstract intellectual effort; they are a product of our inborn territorial instinct. The fact that our emotions can override rational intellectual considerations probably has survival value for the territorial group.

8,20f A man's beard is a territorial flag - The most remarkable evidence of man's aggressive territorial instincts is provided by the male's unusual hair distribution. Natural selection has evolved the beard as a flag to warn off trespassers. Children and women have no beards for the very good reason that they are not generally involved in partrolling and maintaining territorial boundaries. The man's beard is a complete analog to the male lion's mane or the male baboon's ample ruff, where the male of the species aggressively maintains a territory. Modern man carries on his face this flagrant evidence of his aggressive instinctual territorial nature.

The fact that the hairs on the neck of a man underneath the chin grow upward, rather than downward, is explained as a device to make the beard stand out in a showier display. Generally the bigger and better the beard, the stronger and healthier the man behind the beard, and the man, who is more capable of defending or acquiring new territory.

It may be that a bigger and healthier beard is also a sexual sign that leads to greater reproduction success; but such a sexual role for the beard must be quite secondary as compared with its territorial function. Similarly, the male bird's bright feathers and loud song may attract a mate; but their primary function is territorial.

8.20g Man's instincts to kill and torture territorial enemies - Many animal species are known to kill and sometimes to eat members of their own species to gain and or else to maintain a survival territory. Male bears will kill and eat baby bears to help eliminate future competitors for their survival territory. Chimpanzees will kill trespassing chimpanzees. Homo erectus (or Homo habilis), the apparent immediate predecessor to Homo sapiens, killed and ate his



own kind, according to the fossil records, probably as a result of conflicts over territorial hunting rights.

It may be speculated that any lone primitive hunter, who happened to wander into his neighbor's territory, was hunted down, killed, and eaten by the rightful owners of the territory. Cannibalism helped to limit the population on a large area, while putting some food into the stomachs of the survivors.

A vast historical record documents modern man killing his own kind in wars for territory. Genocide and purges have eliminated unwanted occupants of territories desired by conquerors. The historical record also documents man's use of torture and all sorts of atrocities to terrorize his territorial enemies. Cannibalism is also within the repertoire of human behavior. The Astecs ate their criminals and prisoners of war.

It must be stressed that the destruction of members of a species by its own kind can have no lasting effect on the population of the species. Such destruction must remain quite limited. The essential thermodynamic role of life, Eq.(8.3), indicates that the destruction of members of a species by members of the same species cannot detract from the long-time average maximum biomass of the species. Thus, man is primarily occupied in his daily life with raising children and helping his fellow man in order to maintain a maximum biomass of humans.

Never-the-less, the infrequency of deadly conflicts, of wars, and of violence does not signify that man lacks a killing instinct, nor that deadly conflicts, wars, and violence are not important. The winners that survive deadly territorial conflicts are generally capable of putting more combattants into the field; and, being more numerous, they are more evolutionarily fit for survival. Wars and deadly physical conflicts, thus, serve to select the variants and cultures that can maintain a larger biomass of a species.

Man's nature is neither pure love nor pure hate; it is both. Man loves his family, his home, his friends, and his country; and he hates strangers, foreigners, foreign countries, and territorial enemies. (Callan (1970) presents a brief, but interesting, review of the ethology of human aggression.)

## 8.21 The Cause of War is Territoriality

A large variety of possible causes for war were proposed in the seminar that I, as a Fellow at the Center for Advanced Study in the Behavioural Sciences (Stanford California), held during the year 1961–62. None of the proposed causes, such as the failure of two countries to "understand" each other, the failure to "communicate", "unfair" trade practices, or "religious" differences, seemed to be sufficiently compelling to cause war; although such factors are often involved in wars.

Territorial behavior, that involves the life and death struggle to gain and to hold a territory large enough to support its occupants, appears to be a sufficiently important phenomenon to explain the cause of war. Territoriality is a phenomenon involving all forms of life. Variants, best suited to maintain an optimum biomass, are also the variants that survive because they are most capable of winning deadly territorial conflicts. Human cultures, that can support the greatest biomass, the greatest number of humans, per unit area, are also the cultures that win wars. The ultimate test that nature demands is survival following deadly territorial conflicts. Man's genetic territorial instincts drive him into making the ultimate test, into war.

8.21a The war statistics of Lewis Fry Richardson – Direct evidence for territoriality being the basic cause of war can be found in the war statistics gathered by Lewis Fry Richardson (1960), who collected data for wars between 1820 and 1945. If war results from territoriality, then the frequency of wars a country engages in should correlate with the *number* of neighbors the country has. Richardson showed that this is indeed the case. He found for the 38 countries that he investigated that the number of external wars that a country engaged in between 1820 and 1945 with more than 7000 war dead correlated with the number of frontiers the country had.

Richardson also postulated that the number of frontiers a country has should determine, not only the frequency of wars, but should also determine the magnitude of wars T, as measured by the logarithm of the number of war dead $\nu$; thus,

$$T = \log_{10}\nu \propto \text{number of frontiers} \qquad (8.25)$$



Richardson found a correlation; but he failed to obtain precise quantitative agreement.

8.21b War magnitudes as a function of the length of territorial boundaries – Wesley (1974f*) introduced the idea that the rate of deadly territorial conflicts should be proportional to the rate of hostile encounters on territorial boundaries. The rate of such encounters experienced by a territorial group should then be proportional to the *length* of the territorial boundary around the territory held, rather than to simply the number of frontiers or neighbors, as postulated by Richardson. A long physical boundary between two countries with low population densities might afford the same rate of confrontations as a short physical boundary between two countries with high population densities. Thus, it is necessary to convert to a "population space".

A large area A with a total population N may be subdivided into s individual territories of area $a$ each with a mean population n in each; thus,

$$s = A/a = N/n. \qquad (8.26)$$

In this way the physical areas can be converted to population areas.

For individual territories of size n Wesley (1974f) postulated that the rate of deadly conflicts on the large area A, T(n), should be proportional to the total length of all boundaries between such territories, proportional to $s\sqrt{n}$; thus, using Eq. (8.26)

$$T(n) \propto s\sqrt{n} \propto 1/\sqrt{n}\ . \qquad (8.27)$$

The rate of dead produced by deadly territorial conflicts, or wars, equals the frequency of wars between parties of population n each, df/dn, times the number of war dead per war $\nu$; Thus,

$$T(n) = \nu\, df/dn. \qquad (8.28)$$

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* This research was originally published in the *Journal of Conflict Resolution*, 6, 387 (1962) under the title "Frequency of Wars and Geographical Opportunity". It was subsequently reprinted in *Theory and Research on the Causes of War* (Pruitt and Synder 1969). The original explanation in terms of "geographical opportunity" is too *trivial*. The correct explanation is territoriality.

Richardson observed that the number of war dead per war is in general a set fraction k of the population n of each of the waring partners; thus,

$$\nu = 2kn. \tag{8.29}$$

Combining Eqs.(8.29), (8.27) and (8.28) then yields

$$\nu df/d\nu \propto 1/\sqrt{\nu}\ . \tag{8.30}$$

To match the data collected by Richardson the magnitude of a war $\zeta$ is defined as the logarithm of the number of war dead,

$$\zeta = \log_{10}\nu\ . \tag{8.31}$$

Substituting Eq.(8.31) into Eq.(8.30) then yields

$$\log_{10}(df/d\zeta) = C - \zeta/2, \tag{8.32}$$

where C is a constant. This theoretical result is compared with Richardson's data in Table 8.2, where for the best fit C has been chosen as 3.84.

Table 8.2 Frequency of wars and magnitude of wars, Eq.(8.32).

| war dead $\nu$ | magnitude $\zeta$ | frequency of wars $df/d\zeta$ | observed $\log_{10}(df/d\zeta)$ | theory $C - \zeta/2$ |
|---|---|---|---|---|
| $10^3$ | 3 | 198 | 2.30 | 2.34 |
| $10^4$ | 4 | 70 | 1.84 | 1.84 |
| $10^5$ | 5 | 24 | 1,35 | 1.34 |
| $10^6$ | 6 | 6 | 0.78 | 0.84 |
| $10^7$ | 7 | 2 | 0.30 | 0.34 |

The fit between theory and observations is very good. It may be, thus, concluded from the direct observations that wars are, indeed, a consequence of territoriality.



CHAPTER 9

# HAS SCIENTIFIC PHYSICS A FUTURE?

It is of some interest to know if *scientific physics* will survive and flourish in the future, or if it is doomed to extinction. The fate of scientific physics is probably the fate of science in general. An examination of the social forces involved *for* and *against* science may reveal strategies that can further scientific physics and can save it from extinction, such as: founding societies for scientific physics, publishing journals for scientific physics, arranging workshops and international conferences for scientific physics, lobbying for governmental support of scientific physics projects, establishing public relations to disseminate information to the public concerning scientific physics, publishing textbooks for students in scientific physics, establishing scholarships for the study of scientific physics, and offering prizes for outstanding contributions to scientific physics. In other words, perhaps a separate *profession* should be established for scientific physics that is distinct from the current primarily *nonscientific* physics profession.

## 9.1 The Role of Science in the Evolution of Cultures

Science, including scientific physics, concerns knowledge about the real physical material world, or *nature*, that is available to be used by a society or culture to manipulate its physical environment to its own advantage. Since evolution is in the direction of increasing thermodynamic order and thus an increasing biomass; it may be assumed that human cultures evolve to support an ever increasing population of humans together with an attendant increasing mass of thermodynamically ordered compounds in domestic animals, plants,

tools, and machines. Since scientific knowledge permits a greater control over nature and greater thermodynamic order; it may be assumed that human cultures tend to evolve in the direction of greater scientific knowledge and a greater support of science.

Considering the competition for survival among different territorial groups with different cultures, the culture that can support more individuals per unit area, being able to put more warriors into the field, will displace cultures that can support fewer individuals per unit area. Territorial groups with cultures that have the best weapons and ability to make war can displace cultures with poorer weapons and less ability to make war. Scientific knowledge, providing means to support more people and to devise better weapons and ways to wage war, provides a survival advantage.

The great renaissance of scientific knowledge in Western Europe permitted the Western Europeans to conquer the world of peoples ignorant of this knowledge. After hundreds of years the conquered, gaining the scientific knowledge of their conquerors, have largely regained control over their lands. In other words, the physically superior Western European culture has now spread over the entire Earth. The survival value of scientific knowledge for a culture should be evident.

It may be assumed that in general cultures will tend to evolve in the direction of supporting science as something "good" and "desireable" in and of itself. Science and scientists can in general be expected to be honored for putting more food on the table for more people, for putting more warmer clothes on the backs of more people, for providing bigger and better shelters for homes for more people, for providing for the least sickness for the most people, and for providing the best weapons in the struggle to gain and to hold a territory.

A culture that recognizes the value of scientific knowledge generally assigns a positive value to any sort of knowledge, whether scientific or not. Knowledge becomes something "good" in and of itself; while ignorance and superstition become something "bad" or "evil" in and of themselves. Such cultures establish schools, universities, scientific research institutes, libraries, scientific societies, scientific journals, etc. A preservation and furtherance



of scientific knowledge, including scientific physics, would appear to be a natural consequence of cultural evolution itself. On a long-time basis, considering the entire world, it would seem that scientific physics has a secure and certain future, and that there is no need to fear that it will disappear in the future.

## 9.2 Antiscience Cultures Have Existed

Although the power of scientific knowledge favors the survival of a culture; there are many social forces that act against science and scientific knowledge. Even if the long-time survival advantage of science and scientific knowledge means that they will be sponsored in general in the long run; short-time fluctuations have produced drastic antiscience antiknowledge cultures.

The centuries of Greek and Roman culture that sponsored education, the arts, mathematics, science, and knowledge in general were followed by hundreds of years of the "dark ages", when universal ignorance was enforced by the culture imposed by the Christian Church.

The "cultural revolution" in China in the 1960's destroyed institutions dedicated to knowledge and science. Scientific journals were discontinued. Universities were closed. Professors were driven onto the land to work as peasants. The Chinese Communist culture was supposed to return to the "ideal" primitive agrarian society where *everyone* was to be an ignorant peasant. China today in 2002 has still not been able to recover fully from its "cultural revolution". Its knowledge and science is still behind the level it once enjoyed before the "cultural revolution".

Hitler's Nazi culture was dedicated to the suppression of all knowledge and science that was in conflict with its fanatical political and racists beliefs. Jewish and non-German races and cultures were supposed to be dangerous and decadent; and were to be irradicated. The weak, the handicapped, and the ill were to be exterminated to ensure the survival of the most healthy, most superior, "arian" or "nordic" German race. War, involving territorial expansion was glorified as an ultimate "good". Books were burned. Textbooks were rewritten to conform to irrational Nazi beliefs. Professors, scientist, and other intelligentia were forced to leave

Germany. Today in 2002, about 68 years later, Germany has still not been able to recover its relative standing in the world culture of science and knowledge, that it once enjoyed before the advent of Hitler's irrational ignorant beastial Nazi culture.

Pol Pot drove the people out of the cities onto the land to convert the Cambodian culture into an "ideal" primitive ignorant agrarian peasant culture, precisely as sought by the "culural revolution" in China. Opponents of the Red Khmer, especially the educated, the knowledgeable, the teachers, the intelligentia were simply slaughtered.

Perhaps the ancient Greek culture represented by the "atomists", who seemed to have discovered many scientific truths, was destroyed by the subsequent ignorant mystical culture represented by Plato and Aristotle, who championed *insight* and the *mind* over observation and experimentation. And perhaps there have been hundreds or thousands of years when prehistoric cultures prevailed, that were dedicated to ignorance, religion, and anti-science.

Since cultures that have drastically suppressed science and knowledge have actually existed in the past; what is the danger that scientific physics will be destroyed in some such future world culture?

## 9.3 Antiscience Forces in All Cultures

Despite the survival advantage of scientific knowledge, and scientific physics in particular, there are many strong antiscience social forces that persist in all cultures.

9.3a Fear of unknown consequences of science - People, who are ignorant of the precise nature of a particular scientific research project, are likely to fear the possible consequences of such research. The consequences might be catastrophic for mankind. Since the lay public can hardly know what scientists may be doing; a certain fear and suspicion concerning science will always remain in the public mind, which is in part justified.

The widespread use of the very effective DDT insecticide resulted ultimately, after some years, in a world-wide catastrophy. The scientific discovery of DDT ended up in poisoning the environment.



The thalomid tragedy, where the effective sleeping pill, thalidomid, produced thousands of congenital malformations in the babies of women who took the pill during early pregnancy, has understandably contributed to the fear in the public mind of possible unknown catastrophic consequences of scientific research.

Dioxine, the indestructable extremely poisonous compound used in the manufacture of successful insecticides and wood preservatives, has proudced many catastrophies, making many locations more-or-less permanently unsuitable for human habitation. This useful product of chemical science has also given rise to a general fear of possible disastrous unknown consequences of science.

Chlorofluorocarbons, that are chemically so inert and nonreactive, are seemingly ideal as refrigerator coolants and as dielectrics in large electric transformers. But these compounds have produced an unexpected destructive effect on the ozone layer in the upper atmosphere, that shields the Earth's surface from ultraviolet light, that is destructive to life. The chemically inert chlorofluorocarbon compounds act as catalysts in the destruction of the ozone layer. An ozone hole, where the ozone layer has become very thin, has developed over the north and over the south pole, that grows larger every year. A worldwide catastrophy for life on the Earth is now possible. This unexpected effect has also undoubtedly contributed to a general negative attitude toward science.

Although the dangers of science may, in general, be quite minimal in comparison to the possible benefits; very real risks may always be involved. It may, thus, be generally viewed as safer and more secure to restrict knowledge to only *past* knowledge that is *known* to provide successfully for survival. An antiscience social force to limit or prohibit science, due to a fear of its possible unknown catastrophic consequences, exists.

9.3b Fear of known consequences of science - The consequences of scientific research may be *known* and still be feared. Certainly, the intense scientific efforts to develop nuclear bombs, nerve gases, biological weapons, that threaten the existence of all mankind, and are known consequences of scientific research, produce a justifiable fear of science and scientific physics in particular. A desire to halt all physics research becomes understandable.

The worldwide radioactive fallout from numerous continuing atmospheric nuclear bomb tests has produced numerous deaths and congenital malformations, as statistically estimated. Nuclear science is the source of the knowledge necessary to produce this damage to the health of everyone in the world due to this radioactive fallout. It is understandable that the world culture harbors a certain fear of science, and nuclear science in particular, due to this known consequence of science.

Nuclear science has also led the way to nuclear power. Although the energy released is of value; the numerous continuing serious accidents over the years, that have released large amounts of dangerous radioactivity over large areas, have also produced an understandable fear of nuclear power and the science behind it. Probably even worse than the nuclear accidents is the irreversible accumulation of huge quantities of radioactive wastes produced by nuclear power plants, that will remain dangerous for thousands of years. The consequent real danger of poisoning the environment with this permanent ever-increasing radioactive waste has also given rise to an understandable fear of nuclear energy and the science behind it.

## 9.4 The Effect of War on Scientific Physics

Societies and territorial units have always invested a large portion of their available energy in the struggle for more territory or for the preservation of existing territory. Since scientific knowledge provides information that can yield better weapons and means for waging war; societies have generally supported science, and scientific physics in particular, under the assumption that it will provide better "defense" or more effective ways to wage war. Early societies that invented the spear, the throwing stick, the bow and arrow, the sword, the lance, the catapult, the attack tower, etc. undoubtedly invested a large effort for developing and improving upon these devices with a "science" of war.

The agencies for war in modern societies invest heavily in scientific activity, some of it associated directly with weapons and war, but also some support for more basic scientific research. Since, in general, actual results are demanded; the support is



primarily for scientific physics and less for nonscientific physics. Cultures with the greatest real war potential win wars and displace cultures with less capability to wage war. Thus, cultures, that invest in science to improve their ability to make war, survive to invest further in science. The evolution of culture, that depends upon the selection of the cultures best able to wage war, is, thus, in the direction of cultures that support scientific knowledge, and scientific physics in particular.

In recent history the research for war has led to an increase in chemical knowledge in general, that has allowed for advances in chemical warfare, yielding nitroglycerin, TNT, fulminate of mercury, mustard gas, nerve gases, agent orange, cyclone B, etc. The effort to achieve nuclear fission and fusion bombs, and radioactive material for radiological warfare required a huge investment in nuclear science in general.

The development of intercontinental rockets with nuclear warheads for war resulted in the development of rockets that can now send large pay loads into space. Space ships in orbit about the Earth have yielded a large quantity of information about the Earth. Space ships sent to planets, to the moon, and to comets in the solar system have provided a vast quantity of scientific information about the solar system. Space telescopes, free of the atmospheric disturbance for Earth based telescopes, are yielding large quantities of scientific information about the observable universe.

But war produces not only positive social forces for science and scientific physics; war also produces antiwar sentiments and antiscience social forces. The millions of victims in the wars of the 20th century has made war and science unpopular for much of society. The hundreds of thousands of men slaughtered, blinded, and maimed by mustard gas in World War I is not a positive endorsement for Haber's scientific chemical research. Nor are the millions murdered by cyclone B, also developed by Haber, during World War II in German concentration camps a positive endorsement for Haber's scientific chemical research. The hundreds of thousands killed by the nuclear bomb explosions over Hiroshima and Nagasaka can not be used to celebrate the advances in nuclear science.

The defoliation of vast areas of Vietnam by agent orange, so liberally dumped from the air by the Americans in their undeclared war against Vietnam, has also not functioned as a recommendation for scientific chemical research.

The evils of modern war and the science that makes such war possible has given rise to strong antiscience forces in the world culture. Man was more secure and happier before the advent of gun powder, TNT, nerve gas, and nuclear bombs. What sort of horror for mankind will science yield in the future? A certain antiscience sentiment in the current world culture is quite understandable.

## 9.5 Restricted Scientific Knowledge

To avoid antiscience sentiments scientific research in certain areas might be prohibited as dangerous, harmful, and "bad"; while scientific research in other areas might be supported as safe, beneficial, and "good". But it is frequently argued that scientific knowledge itself cannot be classified as either "good" nor "bad"; only the *application* of scientific knowledge can be either "good" or "bad".

However, much scientific effort is directed toward a specific application; so the application and the required scientific knowledge are often inseparable. It may, thus, not always be possible to consider scientific knowledge as merely an abstract concept apart from any application. For example, all of the scientific research to find a cure for AIDS may be regarded as "good" and worth supporting; while scientific research to kill people en masse with the small pox virus to win a biological war may be regarded as "bad" and should not be supported. Edward Teller, who was active in the developement of the hydrogen nuclear bomb, became notorius for recommending and lobbying the U.S. Congress for continued nuclear bomb research. He claimed that nuclear bomb research was neither "good" nor "bad"; and only certain applications of nuclear bombs could be "bad". And the government made the decision with regard to the application and not the scientists.

International treaties have been signed to stop nuclear bomb research and biological warfare research. Unfortunately, there is no certainty that such research has been, in fact, halted. Countries



without nuclear weapons continue nuclear bomb research. Biological warfare research continues under the guise of *defense*. It is claimed that a country needs to know the nature of any possible biological assault; so a proper defense can be found. The small pox virus no longer exists in the population of living human beings; but it continues to exist, stored in vats of liquid nitrogen. The research to presumably "defend" a country against an attack with small pox virus also includes the scientific knowledge of how this plague can be again released upon mankind to "win a war".

A quandry exists: Is it actually possible to dichotomize different research projects as "good" or "bad" so as to thus obtain the good consequences of science while eliminating the bad consequences of science? Ordinarily when the bad consequences of scientific knowledge are recognized, society reacts to protect itself. Children are not allowed to play with potassium cyanide. As science provides us with more and more scientific knowledge, the mechanisms to protect ourselves against the ever increasing dangerous applications of the knowledge must also continue to increase accordingly. Can society keep abreast of the problem? Or would it be better to stop scientific research, including scientific physics research, altogether?

Fundamental science and mathematics, that have perfectly general application in all areas of science, whether "good" or "bad", cannot be classified as "good nor "bad" in and of itself. Fundamental scientific physics is a tool that can be used for both "good" as well as for "evil", like a knife. Fundamental scientific physics, being independent of any immediate application, can, thus, be safely endorsed as valuable scientific knowledge worthy of support.

## 9.6 The Consequences of Status for Science

The problems of status, prestige, reputation, consensus, social institutions, and political decisions affect the progress of science. Today scientists are paid by the society to exercise their role as scientists. The buildings and equipment necessary are paid for by the society. The social forces that provide the flow of money for science can also divert the flow of money into nonscientific or antiscientific channels. The progress and future of science, and scientific physics in particular, is intimately tied to social

forces.

The most important relevant social phenomenon is *status*, pecking rights, or the social rank order of individuals within a social group or within a society.

Since members of the same species have exactly the same needs; the competition for survival is the most intense among the members of the same species. The amount of available food per unit area per unit time for a particular species is generally fixed and limited; so the question becomes: How is this fixed limited amount of food per unit area per unit time distributed among the individual members of a species?

Evolution is in the direction of maximizing the biomass of a species; so the distribution of food and other necessities may be expected to be such as to sustain the largest population. If the competition for the food necessary for survival of individuals were to end up in individuals killing each other in their struggle for survival, the population might be reduced and not maximized. Evolution has, consequently, produced a large variety of strategies for the "peaceful" distribution of the limited food available among members of a particular species to allow an optimum biomass of the species.

Since food is supplied more-or-less evenly distributed over a given area of the Earth, the sunlight available to create the food being more-or-less uniform over the area; evolution, or nature, has yielded the phenomenon of *territoriality*, discussed in the previous Chapter 8. The division of a large area into separate territories, each just large enough for the survival of the individual or the territorial group, optimizes the population of a species on the large area - despite the life and death competition for the limited food available.

For social species, such as man, where a large area is divided into separate survival territories, each occupied by a territorial group of individuals, the division into separate territories, coexisting more-or-less peacefully, resolves the problem of how the limited amount of available food is distributed to each member of the species only partially. The problem of how the limited available food is distributed "peacefully" among the members of the territorial



group remains.

Social insects, such as ants, occupy separate survival territories, or nests, of up to thousands of individuals each. It is not clear how the limited food available is distributed peacefully among the individual members of the nest. It may be assumed that some simple "smart" solution is involved. The word "smart" is used here to denote an ability to solve a particular problem with the fewest neurons. A pocket computer is "smart"; because it can give rapid correct answers to mathematical problems with only a few "neurons", parts, or electronic counters etched on a chip. "Intelligence" also denotes the ability to solve problems. But "intelligence" means the ability to solve many different nonspecific problems. "Intelligence", being able to solve many different problems, requires many neurons. "Intelligence", requiring more time to solve a particular problem, is seldom "smart".

The advantage of "intelligence" over "smartness" is the ability to solve a large variety of problems; while "smartness" is able to solve only an extremely limited range of problems. The disadvantages of "intelligence" compared with "smartness" are the inability of "intelligence" to solve any particular problem quickly and the necessity of carrying around many neurons, that must be kept alive and functioning. A pocket calculator can multiply two 3 digit numbers within a second; whereas, a man without any aids, requires minutes.

Evolution, being in the direction of parsimony, tends to select variants that require the fewest energy expending neurons to solve survival problems, the "smarter" variants. Insects that are highly evolved after many short-lived generations over many millions of years, are "smart" and not "intelligent". The more recent evolutionary trend toward species with more "intelligence", that are not "smart", involves only larger long-lived species, that must apparently solve a larger variety of problems in order to survive. Nevertheless, evolution must still tend to evolve variants that sacrifice "intelligence" for "smartness". Perhaps the larger brained and apparently more intelligent Neanderthal was replaced by the smaller brained less intelligent modern man; because modern man is "smarter".

Modern man is apparently equipped with instinctive "smart"

answers to certain survival problems, where his big "concious" brain is not involved. Certainly muscular reflexes are of this nature. The territorial instinct that makes a man sacrifice himself in battle does not appear to require intelligent rational thought that provides for the survival of the individual. In this case a man's large intelligence is not used; because the instinctive smart answer (self sacrifice) provides for the survival of the home territorial group. Much of the human social behavior seems to be of this nature, being irrational, unintelligent, instinctive, and automatic. Evolution has selected the "smart" solutions that provide for the survival of the human species. These "smart" solutions need not be compatible with the intelligence and rationality of the consciously aware individual human. "Smart" instinctive answers are apparently relagated to the subconcious mind; since the concious mind seems to be preoccupied with rational "intelligent" thought.

Social groups of large animals, occupying a given territory, have evolved status ranking of the individuals in the group to solve the problem of how to distribute the available limited food peacefully among the individuals of the group. In principle, the top of the status rank order eats first. After he is satisfied, the second in rank eats; etc. If there is not enough food available for all individuals, the lower status ranks must go hungry or starve. Once the status rank order of each individual is established, the food is distributed in this way to all members of the group *peacefully*.

The status rank order, the pecking rights, hierarchy of individuals in small social groups may be readily observed to follow the physical strength of the individuals involved. The strongest most capable for physical combat is the alpha male. In principle, the next strongest assumes the next lower rank, etc. In a chicken yard the single male, the cock, dominates all of the hens. The cock can demand the first access to food. It is readily observed that the cock can peck any hen. The hens form a hierarchy of pecking rights. The hen at the top of the hierarchy can peck all of the other hens. The hen with the next lower rank in the pecking order can peck only the hens of lower rank. Etc. The hen with the lowest rank can peck no other hen. This hierarchy is established by the hens pecking each other until it is clear which hen would win in



an open combat with any other hen. The pecking rights hierarchy is a hierarchy of strength, aggressiveness, and good health.

Needless to say, the higher up in the hierarchy of strength, the greater the chance to be well-fed and the greater the chance to have more healthy progeny, than those lower down in the hierarchy. The genes that are thereby favored for perpetuation by this hierarchy of strength are the genes best suited for the physical survival of the species.

Humans are social animals that also form status rank orders on the basis of strength. For small primitive social groups of humans the pecking rights hierarchy is relative simple. Everyone knows his place in the society. For large modern societies, involving millions of individuals, the status hieracrchy becomes very complex. The society is broken up into subgroups, where the rank order is only practised within the subgroup. Farmers do not compete for status with carpenters; and carpenters do not compete for status with dentists; etc. A large modern society becomes a social *web*, where the status ranking occurs in many subgroups. However, a ranking of the status of different subgroups also occurs. Medical doctors enjoy in general a higher status than policemen; etc.

When a social group of humans must act in concert as a single unit, the decisions made are generally left to a single man, the chief, the king, the alpha male, the dictator, the president, or the prime minister, the man highest on the totem pole. This man enjoys, in principle, the highest status possible in the society. Needles to say, the power and strength of a society does not rest upon a single leader with the highest status. The entire society carries out the presumed orders of the leader. The need to obey a high status leader is an instinctive need in humans, transcending rational considerations and conscious intelligence. Hitler enjoyed fanatical support from many Germans simply because of an instinctive need for a Führer.

A human society rank orders its members rigidly in particular roles. Social behavior, being largely based upon instincts, emotions, subconcious needs and drives, forces rather strict conformity to the social norms of the society by every individual member of the society. An individual member of a society, in order to survive optimally,

must fit into their society and must strive to climb the status ladder as high as possible in his own profession, trade, or role.

This "fitting into society" and "status striving", being largely instinctive and "smart", produces thought patterns that are mostly detrimental to rational scientific thought. The need to attain status in human society is, thus, detrimental to science and to scientific physics in particular.

The real breakthroughs in science are usually achieved by single individuals acting independently of their own status needs. An individual, free from usual social pressures, can think clearly, rationally, intelligently, and scientifically. In contrast, the beliefs of a society or a culture, that results from a consensus among higher status individuals, are generally irrational and not scientific. The "group mind" is mentally handicapped; while the "individual mind" can think clearly and rationally.

## 9.7 Ways that Roles and Status Are Revealed

In order for territoriality to function to distribute members of a species optimally over a large area it is necessary for the members of one territorial group be distinguishable from the members of neighboring territorial groups (Section 8.20a). In order for status ranking to function to distribute food and other necessities optimally among the individual members of a territorial group it is necessary for the status rank order of an individual in his role be recognizable.

9.7a Various ways to signify status - Societies have a vast number of ways to reveal the role and status of any particular individual member. Articles of clothing are important indicators of role and status. Overalls indicate something different than a pin striped suit. A black leather jacket with a skull pictured on the back side signifies something different that a beige suede jacket. Other status indicators are bright colored ties, or subdued colored ties, or no tie at all, tennis shoes, or black leather shoes, colored socks, or black socks, a white shirt, or a checkered shirt, a latest mode dress, or an outdated dress, blue jeans, or gaberdine trousers, a tight fitting dress, or a loose fitting dress, high



heeled shoes, and clean clothes, or dirty clothes. The number of ways to indicate an individual's role and status with clothing is seemingly endless.

Hair styles are also indicators of an individual's role and status. A shaved head and chin indicates something different than long hair and a beard. Hair bound high on the head says something different than long hair hanging down the back. The number of ways that hair styles can indicate an individual's role and status is also seemingly endless.

Jewelry, such as rings, necklaces, bracelets, earrings, tie pins, and tiaras can yield much information about an individual's role and status in a society.

An individual's possessions are good indicators of his role, his profession, and his status, such as his tools to perform his job, a large house, or a small house, a large new expensive car, or a small cheap old car, golf clubs, or skies, rifles, or bowling balls, and a cat, or a horse.

The neighborhood in which an individual lives (like a mini-territory) indicates his role and status. The neighborhood and the building in which an individual works also serve to indicate his role and status.

Special buttons, symbols of membership in particular fraternal societies, political parties, or religions may be worn that help to reveal the role and status of an individual.

When all of these visual indicators are not sufficient, vocal indicators are available. High status individuals speak with dialects and accents acceptable and understandable over a larger region and over many status ranks; while low status individuals speak with dialects and accents acceptable and understandable in only a localized region and only for the few lower status ranks.

9.7b Awareness of status is unconscious and instinctive - An individual will generally say what his role is, old or young, male or female, married or single, interested in sports or in politics, and what is job, profession, or trade is; but he will not say what his status rank is, that is appropriate for his role and profession. Generally an individual is not consciously aware of his own status rank. Status ranking is an extremely important social phenomenon;

but it involves subconcious recognition of the cues indicating status and an instinctive response to these cues.

## 9.8 Beliefs Are Important Indicators of Status

More detailed information concerning an individual's role and status beyond the information provided by the cues discussed in Section 9.7 above require communication with the individual. The words, phrases, concepts, and *beliefs*, communicated by an individual indicate his particular profession, job, trade, role, and *status*. Chemists use special words referring to particular compounds, particular chemical reactions, and special laws involving combination percentages, temperatures, quantities of material, etc., which signify absolutely nothing to a nonchemist. This special jargon and concepts serve to classify an individual as a chemist. All jobs, professions, and trades have their own special jargon, that marks an individual as having the particular job, profession , or trade.

What an individual has to say also indicates his status. Different professions, trades and roles have their own particular relative status. In general a medical doctor has a higher status than a plumber. A married mother has a higher status than a spinster. A high school teacher has a higher status than a gardner. Etc. In addition, within each profession, trade, or role there are different status levels. Individuals with high status do not use precisely the same words nor use the words with precisely the same meaning as those with less status within a particular profession, trade, or role. Individuals with high status within a particular profession or trade have slightly different concepts, ideas, and *beliefs* than those with less status. The fine distinctions in status are very important; as every single individual in the society must possess a precise status rank that determines the food and other necessities that are his "rightful" share without any destructive conflicts.

## 9.9 The Role of Religious Beliefs

"Religion" has many different meanings, such as: a set of, rites, rituals, worship, and ceremony; a code for "moral" behavior; a church or organization; a code for healthy living; a temple or



building for rites and rituals; activities that ameliorate poverty, hunger, and sickness among the poor; or sermons and preaching. Of concern here is "religion" as a set of *beliefs*. Webster's dictionary defines "religion" as a set of *beliefs* concerning (among others) the "*purpose* of the *universe*". This presumed definition is devoid of any concrete meaning. How can the "universe", as a collection of objects like galaxies, stars and planets, *think* in order to have a *goal* or *purpose* ? Never-the-less, Webster's presumed definition is significant; because it indicates that the actual defining characteristic of "religion" is a set of *irrational* or *nonsensical beliefs*.

It is sometimes said that "religion" is the "worship of God". When a good Christian, Moslem, or Jew is asked if he believes in "God", he will promptly answer, "Yes!" But when he is then asked who, or what is "God", he can provide no concrete sensible answer. One hears that "God" is supposed to be "the prime mover, the cause, for everything". On the Wesley coat of arms it is stated that "God is love" - an *emotion* and not a *being*! The Bible says that "God" is a "being in man's own image"; and "He" is the "creator of all things". It is completely irrational or insane to *believe* in something that one cannot see, hear, feel, smell, demonstrate, nor even *define* in any concrete sensible way! Again it is clear that the defining property of "religion" is a set of *irrational* or *nonsensical beliefs*.

9.9a The reason for irrational religious beliefs - Considering the vast effect of religion on human cultures, one must ask: Why do individuals, who profess to believe in a particular religion, claim to accept irrational nonsensical beliefs? Science needs an answer for the prevalency of irrational ideas and beliefs held by large numbers of individuals sharing a particular religion. Science is dedicated to rationality based upon solid empirical evidence. The acceptance of irrational or insane ideas and beliefs among a large number of individuals seems to pose an obvious threat to the furtherance of science. Churches and religious organizations are, indeed, usually enemies of science.

The explanation for the prevalence of irrational ideas and beliefs appears to be their use to identify members of a particular

social group from nonmembers. Beliefs, such as: "Rain is wet." "Seeds must be planted to grow crops." "The sun provides light and warmth." cannot be used to distinguish members of a particular social group from nonmembers. Every sane individual in the entire world will accept such beliefs as these as true; so there can be no difference in the beliefs concerning these matters. Thus, these beliefs cannot be used to distinguish one particular social group from another. Since ordinary rational beliefs cannot be used to distiguish members of a group from nonmembers; irrational beliefs devoid of reality must be used to distinguish. Individuals are free to believe or to not believe in invisible gremlins. Beliefs that can be used to distinguish social groups may be chosen from the infinite category of myths, the imagination, and the irrational. An individual professing to believe that "Christ is the son of God." is obviously a Christian and not a non-Christian. A New Guinea native, an Amazon indian, or a Chinese, who have never heard of "Christ", may be readily classified as non-Christians. The idea of a "son of God" has no concrete meaning. This belief, that distinguishes Christians from non-Christians is, thus an irrational religious belief.

Considering this explanation for why irrational beliefs are held by a social group implies that the beliefs themselves are largely a matter of indifference. Appropriate tattoos by members of a particular social group might also function to distinguish members of the group from nonmembers. However, *beliefs* are apparently more effective.

Different social groups are generally engaged in different activities that can have different physical consequences. Thus, a completely adequate explanation for the use of irrational beliefs to distinguish different social groups should rest ultimately upon a *physical* need.

9.9b The need for social groups – The most important distinction between peoples concerns the competition for territory. In order to gain or to retain a survival territory the "we" have to be distinguished from the "they". As explained in Chapter 8, territoriality serves to optimize the total biomass of a species on a large area by the large area being subdivided into small individual survival



territories occupied by individual members of the species or by territorial groups. Humans are social territorial animals. Human territoriality can function only when each neighboring territorial group is individually identifiable. In addition to other devices for identification, territorial groups of humans use distinguishing irrational religious ideas and beliefs. It appears that the most important function of religion is to distinguish different territorial groups; so it exists primarily as a territorial phenomenon.

9.9c Religions serve to bond members of a group together – An irrational religious belief held in common by a large social group, that serves to identify the members of the group from nonmembers, also bonds the members of the group together. The members of a territorial group can thus act together as a unit to repel an invader of their territory. Social groups, bonded together by common irrational religious beliefs, can act cooperatively as a unit to accomplish things that would be impossible for a single human. Thus, commonly held irrational religious beliefs can give rise to the construction of pyramids, cathedrals, fortresses, irrigation systems, roads, and other large projects, where men must act together to achieve a common goal. Primitive men, hunting in cooperative groups, share numerous irrational religious beliefs that bond them together, such as the *spirit* of a dead prey must be thanked ritually for its sacrifice for the group.

Although territoriality provides the greatest and most spectacular need for the common action of the members of a territorial group, and, thus, the greatest need for common irrational religious beliefs; the concerted action of any social group is enhanced by common irrational religious beliefs that bond the members of the group together. It would seem that, in general, the larger the social group and the greater the projects that can be thus achieved, the greater is the need for irrational beliefs.

The socially cohesive role of religion and irrational beliefs is readily confirmed by the assembling of many individual members of a social group together to perform rites and rituals, to sing and dance together, to pray together, and to hear sermons together.

9.9d Irrational religious beliefs are not acquired spontaneously

- The cohesiveness achieved by a religious group is not achieved by each individual of the group acquiring the irrational beliefs by free independent logical thinking. Individual members acquire the required irrational religious beliefs by being "brain washed", by religious teaching, and by incessant indoctrination. Individual members are, thus, forced to believe or to suffer ostracism from the group or worse. Members expressing doubt in "sacred" beliefs may be corporeally punished. "Heretics" have been tortured, maimed, and burned at the stake by the thousands by the Inquisition. To force their beliefs upon their members the Christian Church has banned and burned proscribed books. Free speech is restricted, and censorship prevails in "orthodox" societies. A "church" demands that all members must accept precisely the same irrational beliefs. The consensus found for irrational religious beliefs is achieved by coercion and not by any spontaneous agreement among independent free-thinking individuals. The cohesion achieved by irrational religious beliefs does not mean any rational intelligent free acceptance of these beliefs by the individual members of the group.

The larger a social group and the more tightly their members are bonded together, the greater is the effectiveness of the common actions of the group. Thus, the promulgation and establishment of irrational religious beliefs among many individuals means *power* for the social group and for the leaders of the group (where here the word "power" is used in the ordinary political sense). An individual, who accepts the particular irrational beliefs of a powerful religious group, can expect to enjoy some of the power for his own advantage. The personal motivation to accept nonsensical irrational beliefs in order to *belong* is, thus, clear.

Considering the strong social forces requiring the acceptance of irrational religious beliefs, it is amazing that any science, mathematics, or rational thought at all has been able to survive. Perhaps *scientific physics* can thrive best by "going underground" with research being performed in secret by secret practioners and supporters.

## 9.10 The Nature of Irrational Beliefs

Is there any discernable patterns in the usual irrational religious beliefs that are used to identify social groups? In detail, no patterns can be discerned. Irrational religious beliefs in detail can take on amazingly bizarre forms; but some of the more important irrational religious beliefs are generally strongly anthropomorphic. A head or chief god, such as Zeus, Yahweh, or Allah, represents a "father figure". There are then usually lesser gods representing a "mother figure", a "son figure", a "warrior figure", a "woman sex figure", etc.



There are many irrational beliefs that are supposed to answer certain unanswerable questions involving an individual's perceived internal existence: Where did my consciousess, or soul, come from? Why do I exist? What is the purpose of my existence? Will my consciousness, or soul, live on after my physical death? Why should I suffer pain? Why do I have such a remarkably favorable unique position in the universe? Etc.? These questions cannot, of course, have any rational answers. Some irrational answers to these questions might be: One is put on the Earth to serve God. One has a self awareness, so one can do God's will. One's concious awareness, or soul, will live on after ones physical death in heaven (or in hell), or in the body of another animal. Pain is one's punishment for having sinned against one of God's commandments. One's remarkably favored position in the universe stems from the fact that one is one of God's "chosen people".

Of perhaps lesser importance are the irrational beliefs that are supposed to answer certain unanswerable philosophical, metaphysical, or mystical questions, such as the *nonsense* question implied by the Webster's dictionary definition of "religion"; What is the *purpose* of the *universe*? Other such irrational questions requiring irrational religious answers are: Where did the universe come from? Did the universe have a *beginning* or has it always existed? Why is the universe designed so that certain physical laws are obeyed, only certain animals and minerals exist, light exists, etc.? Is the universe infi te or only fi ite in extent? Will "time" eventually cease to exist? The irrational religious answers might be: God created the universe in 7 days. God designed the universe as it is observed today. The universe is finite bounded by the celestial sphere. Natural time will cease to exist on the "day of judgement".

The Christian Bible, the Jewish Old Testament, and the Moslem Koran are full of hundreds of such detailed irrational beliefs, that need not concern us here.

Since science is supposed to be concerned with rational empirically verifiable beliefs; it is important to note the character of irrational questions that must necessarily lead to irrational answers and beliefs.

## 9.11 Religious Beliefs in the Guise of Physics

Some of the most fundamental beliefs in modern physics today are simply religious beliefs, having no scientific merit nor justification what-so-ever. They are supposed to provide answers to questions that can have no answers - questions that are normally posed only by religions, that provide only arbitrary irrational answers.

For example, did the universe have a beginning in time? This question cannot, of course, be answered. No one has ever observed (nor can ever observe) the "beginning of the universe"! The concept of "time" itself requires observable phenomena in an already existing universe in order to be even *definable*. The question itself is, thus, irrational! Yet many presumably serious sane prestigious physicists claim to *know* that the universe had a beginning in time! The "standard Friedman cosmological model" involves a universe that came suddenly into existence $2.5 \times 10^9$ years ago with a "big bang". Stefan Weinberg (1977), a physicist with high status, even claims that *he knows* precisely what happened during the "first three minutes" following the "big bang". The standard cosmological model also claims to answer the unanswerable question: Is the universe finite or infinite in extent? According to the standard model the universe is supposed to be *finite* in extent. But no one has ever gone to the edge of the universe; nor has anyone ever observed any outer boundary to the universe. Since there is no evidence that can possibly answer this question; the question is unanswerable and is itself an irrational question. A physical theory that purports to answer an unanswerable question is as irrational as the question itself. Such a physical theory is simply a *religion* based upon irrational religious *beliefs*. Most primitive religions choose the



celestial sphere as the outer boundary to a *finite* universe.

In addition, the standard Friedman cosmological model envisions a nonobserved "expanding universe" that is supposed to be in conformity with the nonsensical "general relativity theory". As discussed in Chapters 1, 2, and 3, there is absolutely no scientific basis for these standard cosmological beliefs. The standard modern cosmology is simply a religion in the guise of physics.

The Bible's Genesis and the myths of primitive peoples, presenting stories about a presumed beginning of the universe, have at least some naive charm. The Bible and primitive myths involve no dishonesty, deceit, nor fraud. In contrast the modern cosmological religion presents itself as scientific physics.

The real harm in the modern cosmological religion is the damage it does to scientific physics. Legitimate scientific ideas, such as presented in Chapters 1, 2, and 3, are not allowed in standard physics journals. The powerful religious clique of standard cosmologists enforce their orthodoxy upon the physics community. The general public has become "brain washed" and deceived into believing that the modern standard cosmological religion *is* a *science*. Newspapers, magazines, and television programs devote a large amount of space and time to sponsoring the modern cosmological religion. The "big bang" is presented as having actually occurred, and the universe is supposed to have had actually a beginning, and the universe is supposed to be actually expanding, etc. No time nor space is ever devoted to any sensible scientific cosmology, such as presented here in Chapters 1, 2, and 3.

"Special relativity" is another example of a religion in the guise of *physics* (Galeczki and Marquardt 1997) with its "Lorentz space-time transformation". "Time" is obviously unique and universal. It is an *independent observable* that cannot itself be a *dependent* function of position nor of velocity. Thus, *time* cannot *transform*. The attempt to make time a dependent function of position and velocity, as required by the "Lorentz trnsformation", leads automatically to absurd irresolvable contradictions: How can twins returning from fast round trips be each younger than the other?

Like most religions, "special relativity" is supposed to give universal answers. All physics, all of the laws governing natural

phenomena, are supposed to be "Lorentz covariant". Actually, there are no areas of empirically valid physics that possess the "Lorentz covariant" symmetry!

The founding "postulate" of "special relativity", that the observed oneway velocity of light is always c independent of the velocity of the source or observer, flatly contradicts the observations of Roemer (1677), Halley (1694), Bradley (1728), Sagnac (1913), Michelson-Gale (1925), Conklin (1969), Marinov (1974, 1980a), and others, demonstrating the fact that the observed oneway velocity of light $c^*$ depends upon the absolute velocity of the observer v, such that $c^* = c - v$.

The emotional fanaticism associated with the *belief* in "special relativity" also marks it as an irrational *religion* and not a rational empirical *science*. Einstein is *worshipped* as a sort of god for having given mankind "special relativity". (Actually, Einstein merely plagiarized "special relativity" from Poincaré.) Pennies collected from school children financed the giant grotesque bronze bust of Einstein in Washington D.C. Any paper critical of "special relativity" is treated as heresy and is promptly and automatically rejected for publication by any standard physics journal. Any physicist daring to teach or to present lectures against "special relativity" runs an almost certain risk of losing his job. Although most physicists recognize the empirical and logical absurdities of "special relativity"; they will still say that they believe in "special relativity" in order to keep their jobs and their status. In a society dominated by a strong orthodox religion one must be very careful not to be labelled a "heretic".

It is impossible in this small book to present all of the irrational religious type beliefs that are promulgated in the guise of scientific physics. Most of such irrational and erroneous physics can only be recognized after intense research into the empirical evidence that is relevant and is available. However, this book presents enough examples (in addition to the rather obvious religious modern cosmology and "special relativity") to indicate that there is a big difference between accepted "orthodox physics" and *scientific physics*.



## 9.12 How Do Irrational Physics Beliefs Become Accepted?

The desire to know the answers to question, whether the answers are correct and valid or irrational, leads many individuals to accept irrational answers The desire to *know*, the desire to have the *answers*, is so great that the *scientific merit* of the answers may not be considered. If one *wants* to believe (irrationally) that the universe had a beginning in time, then one will also *want* to believe in the irrational modern standard cosmology as providing the answer to the question of how the universe came into being.

It should not be thought that the strong desire to know the answers and to *believe* is merely a true instinctive thirst for knowledge. It is not! An individual, who claims to know the answers, has a great advantage over the individuals who admit that they do not know the answers. Only the individual who knows the answers has the right to say what is to be done. Those who claim to have the answers have generally the control, or pecking rights, over those who do not know the answers. Thus, the desire to have the answers is primarily a desire for power or higher status in the society. To have the answers is to have a *belief* in the correctness of the answers. Thus, *beliefs* have a higher status over *no beliefs*, over *doubts*, and over *ignorance*. Those who *claim* to *know* rise higher in the status structure of society, than those who admit that they do not *know*.

It is, of course, clear that the correct scientific answers, that provide the ability to control nature, are also desired. An individual, having discovered how to make a better water wheel, has an advantage over his competitor in the water wheel business. Thus, valid scientific answers also provide status in the society. Since the society as a whole is ordinarily unable to distinguish between true scientific answers and psudoscientific answers, or irrational beliefs; it is the *claim* to knowing the answers that ordinarily functions as a status device, rather than the answers themselves. A primitive village will accept the witch doctor's claims, whether they are realistic or not.

However, over long periods it is the social group that knows the correct scientific answers and is, thus, able to support more individuals on a given territory that wins the struggle for survival.

In the long run, the mere *claim* to having the answers cannot be apparently entirely sufficient to establish status.

A legitimate striving to find rational answers to legitimate scientific physics questions can also give rise to erroneous irrational answers. A theory may provide valid answers for a limited set of circumstances or for a limited set of initial empirical data; but it may become untenable or "irrational" when all of the relevant evidence is taken into account, or after more empirical data is collected. Unfortunately, many physics theories, that are only valid for very limited circumstances, are claimed to be universally valid. Since such theories are then in general wrong, not agreeing with all of the available empirical evidence; they constitute irrational physics. The "phlogiston" idea fit some of the early observations of heat transfe ed between bodies; but it is now, fortunately, recognized as untenable as a universally valid concept.

Grassmann's (1849) proposed "simplification" of Ampere's (1823) original law for the force between current elements, that yielded the Biot-Savart law, became accepted; because it gives the observed force between *two* rigid entire closed steady current loops. However, the Biot-Savart law becomes absurd (Wesley 1983a) or irrational when applied to the force on one portion of a closed current loop by the remainder of the loop - the Ampere (1823) bridge experiment. The Biot-Savart law predicts two different answers for the force on the bridge, both of which are smaller than the force observed. The Biot-Savart law is obviously irrational, if it is supposed to give the force between two current elements or between two moving point charges; because it does not even satisfy Newton's third law for this general case (See the following Chapter 10).

The Lorentz force, being an extension of the Biot-Savart law to fields, is, thus, also irrational in general, as it cannot give the force between two current elements or between two moving point charges. Maxwell (1891) electromagnetic theory, based upon the Lorentz force, is in turn irrational as a perfectly generally valid theory.

In the attempt to resolve the real wave-particle problem (How can a wave extending over all space be a particle defined only at a single point?) Born proposed his irrational intrinsic probabilities and "probability $\Psi$ amplitude", Heisenberg proposed his antiscientific experimentally invalidated "uncertainty principle", and Bohr proposed his mystical "complementarity principle". (The rational scientific physics resolution of the wave-particle problem is presented in Chapter 11 below.) Thus, irrational physics beliefs can arise from the striving to find legitimate scientific answers.



The general public, the society as a whole, can also contribute to the acceptance of irrational physics beliefs. Physicists are members of their society. They are also dependent upon their society for their food and other necessities. Physicists will, thus, behave instinctively unconciously and automatically so as to conform to general social requirements and pressures.

The popular press and television are eager to report sensations, anything unusual, contrary to normal expectations, anything "news worthy". The public is eagerly willing to accept any such reported sensation as being based upon actual factual truth. If some physicist, who is presumed to "know", makes a sensational claim, it is given immediate, wide, and lasting coverage in the popular press and on television. "Special relativity" was initially ignored by the physics community as silly irrationality (which it is). Only a very few physicists took it seriously. But the sensational claims of "special relativity" made it *news worthy*. The popular press gave it wide and lasting coverage. The lay public became convinced that it was a real physically valid theory. The whole society became "brain washed". Finally after about 20 years most physicists were forced by their society to *say* that they *believed* in "special relativity" in order to keep their status and their jobs.

No physicist took the irrational "big bang" idea seriously in 1950; but it was such a sensational idea that it has been given wide and lasting publicity and coverage in the popular press and on television. The general lay public, wanting to *believe*, is apparently now convinced that the "big bang" actually gave rise to the universe. And there are probably many physicists today, who feel that they must *say* that they believe the "big bang" actually occurred in order to conform to general social expectations and pressures, necessary to secure their jobs and status.

## 9.13 All-Encompassing Theories Enjoy Higher Status

Since status is given to the man with the answers; the man who claims to have more answers then gains more status. Since only a man, who knows the answers, should be allowed to make the decisions; only a man with the most answers should then have the most power and the most status. A theory or belief that is supposed to yield more answers has more status, than a theory or belief that provides only a few answers. The all-encompassing *belief* that "Lorentz covariance" must be satisfied for *all physics* has more status than the belief that "Lorentz covariance" is limited to the (erroneous) "Maxwell equations" only. A "unified field theory" that is supposed to provide answers to almost everything would provide the highest possible status. The Heisenberg "indeterminacy principle" is a belief, that purports to place a limitation by nature herself on *all* possible experiments and thus on the ability of science to predict. This irrational, antiscientific, empirically invalidated "principle" is so grandiose and all-encompassing, that it has enjoyed great prestige and great acceptance among philosophers, the lay public, and many physicists. A cosmological theory that purports to reveal how the whole universe, that includes everything, came into being has vast prestige over any scientific cosmology that must admit that it is impossible to know if the universe had a beginning in time or not.

For the believers, God is the answer to all possible questions. The complete all-encompassing notion of a God, thus, provides very high status for believers. It is, thus, not surprizing why so many believe in God, and why God remains so popular.

## 9.14 How Are Irrational Physics Beliefs Perpetuated?

Once an irrational physics belief is established with many believers, it plays an important role in the status ranking of physicists among physicists and in the society as a whole.

A society needs status ranking in order to distribute the limited food and other necessities among the individual members of the society peacefully. Without status ranking the competition for the limited available food and necessities might involve violent



physical struggles, ending up in possible murders and blood shed. The stability of the society depends upon the success of its status ranking. Thus, status ranking becomes rigorously enforced by a society.

The beliefs that serve to indicate a particular individual's status *must be accepted* by the individual with this status position in order to assure stability in the society. The introduction of new beliefs, that might disturb the status structure and might lead to violence, blood shed, and chaos. must be discouraged or proscribed. An individual must at least *say* that he accepts the beliefs appropriate for his particular status rank. For example, when the new protestant beliefs were introduced in opposition to the orthodox Catholic beliefs, it led to violence, blood shed, and chaos during the reformation in Western Europe.

In order to force a continued rigid acceptance of irrational physics beliefs, that are used to indicate status, a large variety of devices have evolved: Physics students are "brain washed" by being taught *only* accepted traditional orthodox physics dogma. For example, textbooks for mechanics, electrodynamics, astronomy, modern physics, and optics contain sections devoted to the irrational "special relativity", presented as though it were a legitimate scientific theory. None of its absurd contradictions nor its incompatibility with the empirical evidence are mentioned nor indicated. Such sections are included merely for indoctrination; because they could be omitted without altering any of the actual scientific physics material presented.

*All* of the available texbooks on electrodynamics present *only* the Biot-Savart law, that is irrational and fails as a valid law for the force between current elements and moving charges. Its failure to agree with Newton's third law is conveniently not mentioned. The student is never allowed to even *see* Ampere's all-important empirically correct law for the force between steady current elements. Nor is the student allowed to learn the extremely important Weber electrodynamics. Only the Maxwell electromagnetic theory is presented, that is irrational and fails as a generally valid electrodynamic theory. The standard text books present the Maxwell theory as though it provides the *answers* to *all possible questions* that

one might ever be able to ask concerning electrodynamics. The belief in the Maxwell theory is, thus, propagated in textbooks as an orthodox religion, that excludes all possible contrary beliefs.

Graduate textbooks in quantumt theory contain *only* the Copenhagen quantum mechanics with all of its numerous irrationalities and mysticism, such as: intrinsic probability amplitudes, the indeterminacy principle, the operator approach, matrix mechanics, the de Broglie wave, mathematical supperposition as implying physical causality, the complementary principle, particles existing only when observed, and obserables *defined* as smeared-out integral averages. Only about one third of material in standard textbooks on quantum theory has any actual scientific value. The remaining two thirds is devoted to indoctrination in the irrational mystical Copenhagen school. Scientific quantum theory is presented here in Chapter 11.

Standard graduate textbooks in beginning astronomy present only the standard Friedman cosmology as valid scientific *truth* without a single comment concerning its obvious irrationality.

Since the physics student is required to learn and to *believe* only orthodox, and frequently irrational, material in the standard textbooks; irrational physics beliefs are readily perpetuated. Standard textbooks, thus, serve to "brain wash" the student.

The professors, who teach their physics students out of standard textbooks are frequently unaware of the irrationality of much of the material that they teach; because they themselves were "brain washed" with precisely the same irrational material in the standard textbooks, when they themselves were students.

A student is only awarded a Ph.D. by his professors, when it is clear that he *accepts* and *believes* the orthodox irrational material that he was taught. The status rank accorded a Doctor of Philosophy in physics, is, thus, the status rank associated with orthodoxx irrational physics beliefs. The academic doctoral program is, thus, an effective device to force the perpetuation of irrational physics beliefs. Who wants to lose the status provided by his doctor's degree by denying what he has been taught?

Not only do universities perpetuate irrational physics beliefs through their "brain washed" students. Many other institutions,



such as physical societies, research institutes, and other organizations are actively engaged in forcing the perpetuation of irrational physics. The largest and most powerful physics organization in the world, the American Physical Society (APS), actively sponsors *only orthodox physics* with all of its irrationalities. The APS, being dedicated to orthodoxy, tries to eliminate scientific physics! The many APS sponsored journals are allowed to publish only orthodox material. The many prizes and awards sponsored by the APS are given only to those accepting orthodox physics beliefs. The many meetings organized and sponsored by the APS are dedicated to presenting only orthodox material. The status system must be preserved; and the APS accepts the role of a "church" to preserve the dogmas needed to preserve the status structure.

There are many minor ways to perpetuate irrational status beliefs. There is the "great man" ploy. A "great man" or "genius" has given us the answers; so the answers must be correct and valid. One is diverted from examining irrational beliefs themselves too closely; because it has already been approved as valid by a "great man". An extreme case is the use of Einstein's name as a "great man" or "demigod". He was actually a man of rather limited ability, whose only contribution to scientific physics seems to be a resurrection of Newton's photon to explain the photoelectric effect. The exaggerated status of his name arises from his presumed contributions to irrational or religious physics, such as "special relativity" and "general relativity".

Another ploy to force the perpetuation of irrational physics beliefs is the "consensus ploy". If seemingly all physicists believe something, it must be true. Here again one is supposed to be diverted from considering an irrational belief itself too closely; because it has already been examined and approved as correct by seemingly all physicists. This is a pure status ploy. If one wishes to be accepted as having a particular status rank, then he must accept the beliefs appropriate for the rank. Consensus is primarily a status indicator, having little to do with the rationality of beliefs themselves. One had better believe in God, like every-one-else in the Bible Belt, if one wants to be accepted in the Bible Belt. Consensus means conformity; everyone must accept the same

beliefs to *belong*.

It is true that empirical evidence confirmed by many, rather than only by a few, increases ones confidence in the validity of the evidence. But the evidence itself must be carefully examined; consensus all by itself is not sufficient as scientific physics evidence. Seemingly all physicists can be wrong. They frequently are.

## 9.15 Standard Physics Journals Perpetuate Irrational Physics

Standard physics journals are controlled by the "establishment". The word "establishment" is used here to denote the physicists and institutions that are responsible for the preservation of the status system. The "establishment" is, thus, dedicated to sponsoring high status beliefs and to eliminating low status beliefs. Since high status beliefs are generally irrational; the establishment journals are dedicated primarily to the furtherance of irrational physics and the suppression of scientific physics.

9.15a Ideal selective communication for physics information - The problem facing physicists is how to achieve selective communication. What is to be communicated to whom? A physicist wishing to communicate a brief amount of information to other physicists should be able to submit his material to a central agency, where it can be classified in detail as to content and then stored. When requested by the author and or else by a subsequent recipient of the material, it could be submitted for review by qualified reviewers whose names and comments could be attached to the material. The material could also be transmitted without any such review, when requested by the author or recipient. The brief amount of material with a possible reviewer's comments could then be sent automatically to all those who have a standing order to receive such material in a particular category. Such an ideal selective communication system would be, thus, designed to fulfill the needs and desires of those who wish to send and receive material relevant to each individual physicist's needs.

Such an ideal communication system would circumvent the standard



journal system, that now impedes, rather than facilitates, selective communication.

A fee could, of course, be paid by the participants in the system to finance the system.

9.15b Standard physics journals communicate primarily orthodox physics - Standard establishment physics journals claim to provide the best selective communication to further "physics"; but the "physics" selected to be communicated is limited to orthodox "physics" with its irrationalities. Scientific physics is not selected to be communicated. The ideas, theories, and experimental results of scientific physics are not published in standard prestigious physics journals. Standard physics journals are essentially merely institutions to perpetuate the status system with no serious regard to the actual scientific merit of the material published.

The evidence for the censorship by standard physics journals can be provided by physicists, who have submitted scientific physics material to standard physics journals only to have it rejected; because it does not conform to orthodox physics beliefs. Further evidence of the limited orthodox nature of the material published in standard physics journals, and, thus, the censorship that it implies, is readily indicated by examining the material actually published.

9.15c Ways that standard physics journals censor material - Since standard physics journals solicit manuscripts that are supposed to contain new material relevant to physics as a science; and they are financed and supported on the basis that they further the advance of *scientific physics*; they employ all sorts of dishonest devices to censor out nonorthodox scientific physics material:

Editors claim that they submit manuscripts to qualified referees who are supposed to decide whether or not the manuscript should be published. But at the same time, the names and identity of the purported qualified referees are never divulged. There is, thus, no evidence what-so-ever that manuscripts are actually submitted to any referees, qualified or not. There is no way to check on the qualifications and bona fides of any *secret* referee. As with

the secret witnesses of the Middle Ages, no credance can be given to the opinions of any secret referee.

A standard physics journal often returns to the author excerpts from an alleged referee report, that usually reject the manuscript with some supercillious remarks that indicate that the alleged referee has little or no knowledge concerning the subject of the paper. The real reason for the rejection is usually some departure from orthodox physics beliefs.

Even if the editor of a standard prestigious journal actually does submit a manuscript to a referee, the editor chooses the referee who he feels most qualified to represent the editor's own orthodox physics beliefs. So, in fact, the secret referee ploy allows the editor to perpetuate only his own orthodox beliefs under the guise of having had a manuscript impartially peer reviewed.

In the struggle against competitors for status, beliefs are important. If a referee reviews a manuscript that opposes his own beliefs, and thereby threatens his own status, he will vigorously reject the manuscript. His dishonest self-serving decision is conveniently hidden by his anonymity as a secret referee.

A secret referee, reviewing a paper with a good idea or theory can with impunity reject the paper for publication in order to publish the idea or theory later under his own name, as the originator of the idea or theory. An author has no protection against such theft by a secret referee.

Similarly a secret referee can delay the publication of a paper; so that the referee can have priority in the publication of an application of a good idea or theory. (Such as Born and Heisenberg, acting as referees, held up the publication of Schroedinger's papers; so they could be first to publish the application of the Schroedinger theory to scattering and to the helium atom (ironically incorrectly done).)

When the secret referee ploy fails and a secret referee accepts a paper that the editor wants rejected, then the editor can simply ignore his referee and reject the paper himself. Gutman, the editor of the standard APS *Journal of Applied Physics*, once rejected a paper of mine, indicating the empirical absurdity of the Biot-Savart law, that was accepted by three of his own secret referees. Gutman



was outraged that anyone would question the validity of the orthodox Biot-Savart law.

In recent years it has become rather common for a standard physics journal to acknowledge receipt of a paper, but to refuse any further correspondence concerning the paper. Being apparently unacceptable to an orthodox editor, the paper disappears immediately into a waste basket. By refusing to submit the paper for refereeing and by refusing to respond to all enquiries about what may have happened to the paper an editor of a standard journal is able to most expeditiously defend the orthodox faith against heretical beliefs. An author physicist has no recourse against such dishonesty.

Another ploy is to return a paper, containing scientific beliefs unacceptable to an orthodox editor, with a note stating that the manuscript is not appropriate for the journal; even though it is, in fact, precisely in the appropriate area as stated in the preface to the journal itself.

9.15d Physics journal system limits the rate of communication – In a communication netweork of n individuals there are $n(n-1)/2$ possible channels of communication. In a telephone network each message is generated and communicated only once. The rate of communication in a telephone network, thus, varies as the number of subscribers, n. In the standard physics journal system a paper or message, generated by any one author subscriber is communicated to *all* other n subscribers; so the rate that messages are sent tends to increase as $n(n-1)/2$ or as $n^2$. As n becomes large (such as for the *Physical Review*) the number of pages, as pieces of paper, that must be distributed, varying as $n^2$, becomes huge.

Because status, social prestige, and power requires as great a consensus as possible among as many members of the society as possible; the articles and beliefs published by a standard physics journal *must* be distributed to as many individuals as possible. An individual physicist, as a victim of this system, *must* therefore receive and pay for a huge amount of material that is of no use or value for him. Out of a thousand pages published by a journal per year perhaps only one or two pages is of any interest or is of any value to any particular individual physicist.

The standard physics journal system is, thus, not selective.

It is like a telephone system, where *all* of the subscribers try to talk simultaneously to *all* other subscribers. If a particular paper were to be sent *only* to those interested in the particular paper, then the number of pages, as pieces of paper distributed, could be reduced by perhaps a factor of n. Or, if the same amount of pages, as pieces of paper distributed, were to remain the same, the amount of information selectively distributed could be increased by perhaps a factor of n.

The well publicized "publication glut" does not mean a glut of *information* communicated; it merely means a glut of *paper* distributed. Instead, the "publication glut" indicates that the present physics journal system lacks adequate selectivity, which severely limits the amount of information communicated. A proper selective communication network would tend to have a message transmittal rate varying as only n and not as $n^2$.

The standard physics journal system, being not properly selective, uses the excuse of a "publication glut" to restrict the amount of information communicated. The less the amount of information, the fewer the ideas, and the fewer the beliefs that need be communicated. The fewer the ideas and beliefs communicated, the easier it is to limit the material published to only proper acceptable orthodox material. Truly new serious scientific physics finds no space in standard physics journals.

9.15e Archiving of irrational physics beliefs – Most of the physics information that is archived in libraries is contained in collections of standard physics journals on paper. Since standard physics journals publish essentially only orthodox largely irrational physics; the physics information perpetuated for future generations is limited to primarily irrational physics beliefs. Scientific physics is hardly represented in library archives.

## 9.16 Ways that Scientific Physics Can Be Communicated

The powerful status forces that presently restrict the communication of scientific physics can be circumvented. Scientific physics information can be communicated through private letters, by telephone, by fax, or by e-mail. Scientific physics is also



published in a few small dissident journals, that are fortunately abstracted in *Physics Abstracts*; so the information is, thus, accessible to all.

Electronic communication would seem to provide the opportunity to establish a more-or-less ideal selective communication system, such as discussed in Section 9.15 above. Physicists using their own personal computers could submit electronically manuscripts to a central electronic clearing house, where it could be categorized in great detail (a most serious software problem) and then stored in an electronic random access archive. A physicist could request electronically from the archive material belonging in a very special category. The material from the archive could then be read off of the monitor and printed out, if desired. Evaluations of the manuscript by known reviewers might also be requested from the central clearing house. The reviewer's report could then be also stored to also be retrievable. The fantastic amount of information that can now be transmitted and stored should provide no limitations on communication (such as now imposed by the standard physics journal system). The only limits would then be imposed by the authors and readers themselves.

Physics journals are now available through internet, an electronic archive. And individuals can now publish electronically material as a "web page", which is uncensored, but is, unfortunately also not catagorized for any proper selective access.

The physical possibilities are now present electronically for an essentially ideal communication system for scientific physics; but the problem of how to achieve the desired selectivity remains. How does an author put his material before the reader who wishes to read this material? In addition, how can such a communication system be used to establish status? Status is, after all, important for a proper functioning society. At the same time, how can status ranking be established without the apparently necessary irrational beliefs, that now interfere with the furtherance of scientific physics?

## 9.17 Scientific Physics Is Not Funded

The status structure of a society provides the means for

distributing food and other necessities among the members of the society peacefully. The amount of money an individual or group receives as income is generally a measure of the quantity of food, necessities, and other goods that the individual or group receives. Thus, in general, the amount of money an individual or group receives is a measure of the status rank they enjoy. Since higher status beliefs in physics are largely irrational and not scientific; most of the funds for physics is disbursed for irrational physics and little or none for scientific physics.

9.17a Administrative costs for physics research - Most of the money allocated for physics research is siphoned off as "administrative costs".

The status of an administrator rests upon the number of men under him and the amount of money he controls or administers. Thus, to increase their status administrators strive to have more men under them costing more money. There are always excuses that can be invented to warrant more men or more bureaus under an administrator. The status structure of governmental administrations allocating funds for physics research, consequently, evolve into an ever growing pyramid of agencies, bureaus, sections, etc., costing an ever growing percentage of the money allocated for physics research.

An individual physicist responsible for a research project receives only the money that is able to trickle down through the bureaurocratic pyramid. Each bureau in the pyramid syphons off funds for its own administrative costs. It may be conservatively estimated that more than 80% of the funds allocated for physics research today ends up as administrative costs.

9,17b No money is awarded to the physicist doing the research - Although once, many years ago, a particular individual physicist might receive money directly from a legislative or other high level governmental agency for a particular research project; this is no longer done. No money is now awarded directly to any individual physicist, who is responsible for getting the proposed research done. Instead the money is paid *only* to universties and research institutes. This deplorable practice has evolved, so granting agencies can avoid all responsibility in case the funds are not



properly used. The more institutions and the more administrators between the granting agency and the research physicist, the more difficult it is to discover *who* might have made a mistake. Administrators want to enjoy the priviledges of their status positions and control over funds without having to be made responsible for their decisions.

A physicist is expected to write a research proposal with a request for a grant of money from some government or private funding agency. Before the proposal can be sent to the funding agency it must pass through a gauntlet of administrators of the physicists own institution. A professor must obtain the approval of his department chairman, the dean of the colledge, and the president's front office. In a research institute the research proposal must be first approved by the section head, by the division head, and by the director's front office. Once the proposal is approved by the university or research institute, it is transmitted in the name of the university or research institute to the governmental funding agency. The physicist, who must do the work, is only mentioned in the proposal as the "chief investigator". The money requested is to be paid to the university or research institute; it is not to be paid to the physicists, who must decide how the money is disbursed to get the research done.

A physicist, who is not affiliated with a university or research institute, cannot submit a proposal to a governmental funding agency. As a consequence the most important independent scientific physics research projects are not funded.

9.17c Universities and research institutes do not fund scientific physics - The administrators of universities and research institutes have little interest in sponsoring any actual physics research. In general, they have no physics education and have no idea as to the merit of any particular physics research proposal. Administrators function merely to preserve and to increase their own status by trying to get as much money as possible for their university or institute. To increase the likelihood of obtaining money for their institution administrators sponsor *high status safe* research, that can only confirm established orthodoxy. Since high status physics

beliefs are largely irrational physics beliefs; administrators sponsor irrational physics and not scientific physics. Valuable high risk scientific physics research, that may have a greater likelihood of producing no positive results and that might give the university or research institute a "bad name" is not approved.

It might seem absurd that physics beliefs can be associated with an institution; but they are! For example, the research in "paranormal phenomena" done at Duke University and Stanford Research Institute have been detrimental to their reputations. While at the Livermore Radiation Laboratory I had to place my home address, instead of my Laboratory address, on my published paper, entitled "Background Radiation as the Cause of Congenital Malformation" (Wesley, 1960); because Teller, the Director of the Laboratory, wished the belief that "a little bit of radioactivity is harmless" be identified with the Laboratory. Similarly, Teller, a fanatical believer in Copenhagen quantum mechanics, wishing the Copenhagen beliefs be identified with the Laboratory, tried to dissuade me from my scientific quantum theory research (presented in Chapter 11 below). Being unable to dissuade me from my scientific beliefs, Teller finally said, "Wesley, you will lose your reputation, if you persist in your research (into scientific quantum theory)!"

9.17d The overhead swindle - A university or research institute, submitting a research proposal to a government funding agency, attaches a request for "overhead", which is generally now about 120% of the costs to do the research. The money is not to be used to provide laboratory space nor any other such peripheral costs to enable the research to be done. Instead it is a pure gift to the administrators of the university or research institute to disburse as they might wish. Actual overhead costs are already included as part of costs to do the research. In addition, these actual peripheral overhead costs are usual ordinary maintainance costs that must be paid, whether the research is done or not.

Without the unjustified "overhead" more than double the amount of research could be accomplished.

Administrators ordinarily use such "overhead" to hinder the accomplishment of the proposed research. The money is usually spent



to create more administrative positions with more administrators, who, to make themselves important, withhold funds necessary to get the research done, require more forms be filled out, and generally hinder the physicist in his attempt to accomplish the research promised. Money that is given as a gift to administrators, generally, results in a larger superstructure of administrators, who hamper rather than facilitate the actual work that has to be done.

9.17e Funding agencies award grants for safe orthodox physics - Since generally the employees and administrators in a government funding agency are not capable of evaluating the merit of any particular proposed physics research project; "peer reviews" of proposals are sought. Unfortunately, the peer reviewing is generally secret; so the physicist responsible for the research has no chance to check the qualifications of the reviewer nor does he even have a chance to read the reviewer's report. Since there is no proper control over the peer review system; government funding agencies award research grants on the basis of status. To perpetuate the status structure research grants are awarded to projects with the highest status. Thus, only safe high status orthodox physics projects are funded, which means that money is awarded to perpetuate irrational physics instead of scientific physics.

Some technical and engineering progress is, never-the-less, accidentally or serendipitally achieved by this method of government funding. But generally this method of funding stifles progress in any real fundamental scientific physics.

9.17f Big money for less physics research - Government agencies, universities, and research instututes are now involved in *big business*. Huge amounts of money are given to build gigantic particle accelerators, storage rings, colliders, and presumed neutrino counters, not to mention the vast sums wasted in the fruitless attempt to attain a controlled thermonuclear reactor, that would further poison the environment with vast neutron produced radio-activity.

Particle accelerators, yielding one new particle for the particle zoo about every 5 years with vanishing half-lives, have been spectacularly worthless in terms of the money spent to the amount of

scientific information gained. There is never any attempt to use these huge devices to do any real physics research in the high energy range, that would reveal how mass might actually change with velocity or that would yield the actual empirical laws for high energy electrodynamics. It is merely assumed that mass changes with velocity as the gamma factor, $m = m_o\gamma = m_o/\sqrt{1 - v^2/c^2}$. And the electrodynamics is merely assumed to be given by the erroneous Maxwell theory.

In contrast to the big money projects, that yield no new fundamental scientific physics principles, there are many small research projects, costing almost nothing, that, if financed, could readily advance fundamental scientific physics tremendously. For example, a repetition of Marinov's brilliant coupled mirrors experiment, costing almost nothing, could finally lay to rest the "special and general relativity" nonsense.

Since university and research institute administrators are interested only in status and money received; they have no interest in small research projects, that can bring in no real money and pose a threat to the existing status structure. Only big research can bring in big money through big "overheads". Big money projects have driven small money projects out of business. Small research projects are regarded as merely a nuisance; they are not sponsored by univerity and research institute administrators. Yet the scientific value of small money research is immeasureably greater than the very limited scientific value of big money research.

## 9.18 How Scientific Physics Should Be Funded

Grants should be awarded directly to the individual physicist responsible for doing the research Administrators of universities and research institutes are not qualified to make the necessary decisions of how the grant money should be spent to get the research done. The amount of research done by the man actually responsible for disbursing the money could be, thus, drastically increased. Much of the huge administrative costs by governmental, university, and institutional bureaucracy could be thereby avoided. The research physicist, receiving the grant directly, could be readily held



responsible for the correct disbursement of funds. There would be no huge expensive administrative maze to hide accountability.

With research grants awarded directly to the research physicist responsible would open up the opportunity to take advantage of the many very worthwhile research projects proposed by physicists not affiliated with any institution. Institutional affiliation should not be a requirement for the eligibility to submit research proposals.

Government granting agencies should be required to apportion a much larger percentage of their funds for small grants, and correspondingly less for large grants, the value of small grants being immeasureably more worthwhile for the money than large grants.

It can be expected that research requiring small grants will tend to involve research projects with greater risk of failure. But, when the unknown is to be really explored, one cannot be sure as to what one might discover. In general, the higher the risk, the more significant the research might be. Disbursing the available government money among many small research projects provides a much greater chance that a few of the projects will yield truly important breakthroughs. Disbursing the available funds to only a few safe large research projects, where there can be no failures, guarantees the discovery of nothing truly new nor important.

Because it is impossible, even with the best honest peer reviewing, for a government agency to understand completely the physics involved in any particular proposed research project; it is best to be lenient in the appraisal of small research proposals. Government funding agencies should invest a little money in some projects, which they cannot understand, in order to optimize the possibility of obtaining some real scientific breakthroughs. A government administrator in a funding agency, who has awarded a grant to a small "lunatic project" should not suffer a loss of status; because the optimum strategy for the disbursement of funds to achieve the best research results must include such occasional losses.

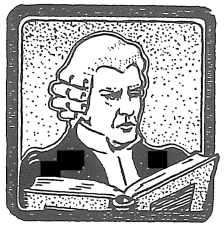
There should be no secret peer reviewing requested by a government funding agency concerning the merit of a particular research proposal. The names and bonifides of all reviewers should be affixed to their reviews, which should be then also available to

the physicist requesting the grant. An open public evaluation of the scientific merit of a proposal would help to enhance the quality of the research funded.

In order to break the strangle hold that *orthodoxy* demands upon all grants awarded, there should be some regulation that a government funding agency must award a certain fraction of their funds to dissident research projects, that are endorsed by a minimum number of qualified physicists, listed on the submitted research proposal.

There should be no automatic huge "overhead" awarded to the administrators of universities and research institutes, where a research physicist has obtained a research grant. The research physicist himself, being aware of the needs to achieve the research results, is the most competent to judge what the actual overhead costs might be. When the administrators of universities and research institutes no longer receive the unwarranted "overhead" gift, they will no longer hamper the work necessary to get the research done. And the administrators will be no longer motivated to impose the most acceptable prestigious orthodox money-making beliefs upon the research physicist affiliated with their institution.

The suggestions presented in the present Section, if instituted, would probably represent an upheaval in the present rigid status system. But, if scientific physics research is to ever be actually properly funded, such an upheaval is necessary!





CHAPTER 10

# VALIDITY OF AMPERE'S FORCE LAW

Ampere (1823), following a series of brilliant experiments for the force $d^2\mathbf{F}_A$ on a current element $Id\mathbf{s}$ at $\mathbf{r}$ due to a current element $I'd\mathbf{s}'$ at $\mathbf{r}'$ proposed the force law

$$d^2\mathbf{F}_A = (II'\mathbf{R}/R^3)\left[-2d\mathbf{s}\cdot d\mathbf{s}' + 3(d\mathbf{s}\cdot\mathbf{R})(d\mathbf{s}'\cdot\mathbf{R})/R^2\right], \qquad (10.1)$$

where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$ and $I$ and $I'$ are in abamperes (as already given by Eq.(4.10)).

Most of Ampere's evidence for his law (10.1) concerned the net force between two entire mechanically rigid closed current loops. Only the Ampere bridge experiment (discussed in Sections 10.2 to 10.4 below) involves the force on a portion of a current loop caused by the remaining portion of the loop. Ampere (and subsequently numerous others) observed qualitatively a repulsive force on the bridge in agreement with his law for the force between colinear current elements. Since Ampere obtained no quantitative value for the force on the bridge, neither theoretically nor experimentally; the validity of Ampere's law (10.1) has remained in question since 1823.

## 10.1 Alternative Laws Proposed for the Force Between Two Current Elements

Many alternatives to Ampere's law (10.1) have been proposed since 1823 for the force between two current elements (as discussed by O'Rahilly (1965) and Assis (1994)). Most of these alternatives are not acceptable; as they violate Newton's third law, or they do not yield the observed force between two rigid closed current loops, or they assume some other unrealistic condition, such as

both positive and negative carries in current carrying wires.

10.1a Grassmann's law - Grassmann (1845) claimed erroneously that only closed rigid current loops could exist; and, thus, isolated current elements were impossible. Today it is well known that electric currents in wires are produced by a flux of negatively charged electrons; so moving charges can, in fact, constitute isolated current elements; and currents are not thereby limited to closed current loops. Oscillating currents can, for example, flow out and back along a portion of straight wire to charge and discharge a condenser plate, or to drive an electric dipole antenna; and no closed current loop is involved.

Grassmann, noting the identity

$$(d/ds')(1/R^3) = 3(ds'\cdot R)/R^5 \ , \tag{10.2}$$

integrated the second term on the right of Ampere's law (10.1) by parts to obtain for a primed rigid closed current loop

$$\oint' 3(ds\cdot R)(ds'\cdot R)R/R^5 = (ds\cdot R)R/R^3\Big|_0^0 + \oint' (ds\cdot ds')R/R^3 + \oint' \left[(ds\cdot R)/R^3\right]ds' . \tag{10.3}$$

Substituting this result (10.3) (assuming a rigid closed current loop is involved) into (10.1) then yields Grassmann's law for the force $d^2F_G$ on a current element Ids at r due to a current element I'ds' at r' as

$$d^2F_G = (II'/R^3)\left[-(ds\cdot ds')R + (ds\cdot R)ds'\right] = II'ds \times (ds' \times R)/R^3 . \tag{10.4}$$

(This Grassmann law is generally inappropriately referred to as the "Biot-Savart law". Biot (1829) and Savart obtained only the force on a magnetic pole given by a current element; which is equivalent to obtaining the magnetic B field produced by a current element; thus, $dB = I'ds' \times R/R^3$.)

This Grassmann law (10.4) clearly violates Newton's third law; as it does not act along the line joining the two current elements R; and interchanging primes and unprimes does not yield the negative reaction force. However, being derived from Ampere's law it satisfies Newton's third law when integrated around an entire closed rigid current loop.

This Grassmann-Biot-Savart force (10.4) acts perpendicularly to



the current element Ids. Thus, this force assumes that the longitudinal force on the current element is zero. In particular, any arbitrarily chosen force acting longitudinally on a current element will necessarily integrate to zero around a closed mechanically rigid current loop. The net force between two rigid current loops can, thus, never reveal any longitudinal force that might be acting on a current element. The Ampere force (10.1) prescribes such a longitudinal force between colinear current elements given as the repulsion

$$d^2F_A(\text{colinear}) = II'ds\,ds'/R^2 . \tag{10.5}$$

The Ampere bridge experiment (Section 10.2 below) does not involve *two* rigid current loops, but only *one* current loop, where force elements are *not* integrated around a closed mechanically rigid loop, but only over a portion of the single current loop. Thus, in this case the longitudinal component of the force on a current element does not integrate to zero. An integration of the Grassmann-Biot-Savart law over the Ampere bridge (Section 10.4 below) yields an absurdity.

10.1b The F. E. Neumann (1845, 1847, 1884) force law - It is usually claimed that Ampere's force law is uniquely chosen from the evidence for the force between two rigid current loops by requiring Newton's third law be satisfied for the force between two current elements. *This is not true*; as an alternative force law for the force between current elements satisfying Newton's third law may be readily obtained. In particular, noting that the last term on the right of Eq.(10.3) is zero when integrated around a mechanically rigid closed unprimed current loop; thus.

$$ds' \oint (ds\cdot R)/R^3 = -\,ds' \oint ds(d/ds)(1/R) = -\,ds'\Big|_0^0 = 0. \tag{10.6}$$

Substituting this result (10.6) into (10.3) yields the F. E. Neumann force $d^2F_N$ on Ids at r due to I'ds' at r'; thus,

$$d^2F_N = -\,II'(ds\cdot ds')R/R^3 \ , \tag{10.7}$$

which clearly satisfies Newton's third law.

This Neumann force (10.7), satisfying Newton's third law, is the simplest acceptable force law yielding the net force between two rigid closed current loops. For the case of the net force between

two closed rigid current loops the F. E. Neumann force is as valid as the Ampere force law (10.1). However, the two laws are not equivalent for the force between current elements. The F. E. Neumann force (10.7) predicts a force of attraction between colinear current elements; while Ampere's law predicts a repulsion, as given by Eq.(10.5).

Other appropriate acceptable condidates for the force between two current elements, that satisfy Newton's third law and that yield the net force between two closed rigid current loops, may be obtained from the linear combination

$$d^2\mathbf{F}(\text{possible}) = \alpha d^2\mathbf{F}_N + (1 - \alpha)d^2\mathbf{F}_A \ , \tag{10.8}$$

where $d^2\mathbf{F}_N$ is given by Eq.(10.7) and $d^2\mathbf{F}_A$ by (10.1), and where $\alpha$ is a constant that must be determined by experiments, other than the force between two closed rigid current loops. The Ampere bridge experiment (Section 10.4 below) is such an experiment.

It is not clear why Ampere chose $\alpha = 0$ in Eq.(10.8), considering the insufficient quantitative information then available.

The F. E. Neumann force, Eq.(10.7), is best known in terms of the F. E. Neumann scalar potential $U_N$ defined by

$$U_N = - II' \oint\oint ds\cdot ds'/R = - I \oint ds\cdot A = - \int d^3rJ\cdot A, \tag{10.9}$$

where $\mathbf{A}$ is the vector magnetic potential and $\mathbf{J}$ is the current density. The F. E. Neumann force, Eq.(10.7) is then given by $\mathbf{F}_N = - \nabla U_N$. The electrodynamics of slowly varying effects involving two closed rigid current loops is conveniently prescribed in terms of the F. E. Neumann scalar potential, Eq.(10.9).

F. E. Neumann also considered induction. The emf around one closed loop due to a time changing field produced by another loop is given by

$$\text{emf} = - (d/dt)\oint\oint I'ds\cdot ds'/R = - (d/dt) \oint ds\cdot A. \tag{10.10}$$

Using Stokes' theorem this result (10.10) is the same as the misleading Faraday law of electromagnetic induction, where the magnetic $\mathbf{B}$ field, defined by $\mathbf{B} = \nabla \times \mathbf{A}$, must be known over the entire area enclosed by the loop, instead of in the wire itself, where the actual induction takes place. This F. E. Neumann induction formula (10.10) is in agreement with the force of induction on a charge q, given



by $\mathbf{F}(\text{induction}) = - qdA/dt$ (as in Chapter 5) for a rigid loop.

## 10.2 The Ampere Bridge Experiment

To demonstrate the existence of a repulsion between colinear current elements and to demonstrate the failure of the Biot-Savart law (10.4) Ampere devised the Ampere bridge experiment indicated in Fig. 10.1.

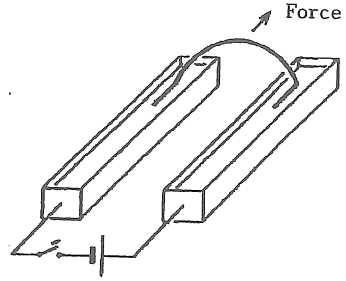



Fig. 10.1 The Ampere bridge setup.

Two parallel mercury filled troughs are connected to a battery. A $\Pi$ shaped metal wire "bridge" connects the two mercury filled troughs, as shown in Fig. 10.1. When current flows, in either direction, the bridge is propelled in the direction away from the battery. The force on the bridge can only be due to the remaining fixed portion of the current loop. Ampere reasoned that the force of repulsion was primarily due to the colinear current elements in the legs of the bridge, as given by Eq.(10.5).

The alternative simplest force law valid for an entire rigid closed current loop, the F. E. Neumann force law (10.7), yields a force of attraction on the Ampere bridge which is not observed. Never-the-less, when the F. E. Neumann force is combined with the Ampere force, according to Eq.(10.8), it may permit a more accurate quantitative fit for the force on the Ampere bridge.

## 10.3 The Force on the Bridge Predicted by Ampere's Law

Linear current elements, Ids and I'ds', as given in Eqs.(10.1) and (10.7), are idealizations that do not exist in nature. The flowing electrons that yield the observed current are distributed

throughout an element of volume; they are not lined up along a geometrical line. Thus, only volume current densities can be physically real. When colinear current elements are brought together (as in the Ampere bridge experiment) so that $\mathbb{R} = 0$, idealized linear current elements yield a physically impossible infinite force, as indicated by Eq.(10.1). In contrast physically real volume current densities yield a finite noninfinite force when $\mathbb{R} = 0$. Attempts to calculate the force on Ampere's bridge using unrealistic linear current elements have yielded primarily arbitrarily chosen results (Hering 1923, Cleveland 1936, Dunton 1937, Robertson 1945, Moyssides 1959, Graneau 1994, and Assis 1994b). The most serious obstacle in testing Ampere's law (10.1) has been the absence of an exact theoretical expression for the force on Ampere's bridge, which is now given by Eq.(10.17) for the first time for wires of circular cross section.

Linear current elements are, of course legitimate useful approximations for thin wires of radius b when the separation distance is large compared with the radius of the wire, $R >> b$.

In order to be completely physically realistic the Ampere law given by Eq.(10.1) needs to be rewritten in terms of volume current elements (as already stressed by Wesley 1982, 1983, 1987, 1990, 1991, 1996, and 1997); thus,

$$d^2F_A = (\mathbb{R}/R^3)\left[-2J\cdot J' + 3(J\cdot\mathbb{R})(J'\cdot\mathbb{R})/R^2\right]d^3r\, d^3r'. \qquad (10.11)$$

The *exact* theoretical expression in closed form for the Ampere force on the Ampere bridge for wires of circular cross section has been obtained from Eq.(10.11) and is presented here in Eq.(10.19) below. The exact expression in closed form for wires of rectangular cross section has already been given by Wesley (1991s).

The Ampere bridge circuit is indicated in Fig. 10.2 for computational purposes, where portions 3, 4, and 5 constitute the bridge: and portions 1, 2, and 6 constitute the remainder of the fixed circuit.

The force between two portions of the circuit that are not in direct contact may be computed using the convenient linear approximation for the Ampere's law, given by Eq.(10.1); since the wire leads may be assumed to be thin in comparison to the other dimensions of



of the circuit. The integration for these forces may be easily evaluated in closed form using elementary functions.

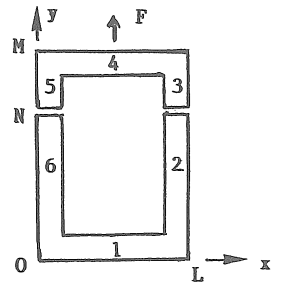



Fig. 10.2 Diagram of Ampere's bridge for the computations.

The force between two portions in direct contact carrying colinear volume current elements, between 5 and 6 and between 2 and 3, must be calculated using Ampere's force law (10.11) in terms of volume current densities. Referring to Fig. 10.2, the distance between current elements in this case is given by

$$R^2 = (y - y')^2 + \zeta^2 + \zeta'^2 - 2\zeta\zeta'\cos(\phi - \phi'). \qquad (10.12)$$

where $\zeta$ and $\zeta'$ are radial distances from the centers of the wires of circular cross section; and $\phi$ and $\phi'$ are the angular positions of the volume current elements within the wire. No infinite singularities can possibly arise. The y component of the Ampere force Eq.(10.11) on the two legs of the bridge then becomes

$$F_{Ay}(\text{contact}) = 2J^2\int\int d\zeta d\zeta' \int_M^N dy \int_N^O dy' \left[-2(y - y')/R^3 + 3(y - y')/R^5\right], \qquad (10.13)$$

$$= 2I^2\left\{-1 + ln\,2 - ln\left[M/(M-N)\right] + ln(N/b)\right\} + F_S\,,$$

where the "singularity" term $F_S$ is given by (10.14)

$$F_S = -2I^2 ln\, b - J^2\int_o^{2\pi} d\phi \int_o^b \zeta d\zeta \int_o^{2\pi} d\phi' \int_o^b \zeta' d\zeta' ln\left[\zeta^2 + \zeta'^2 + 2\zeta\zeta'\cos(\phi - \phi')\right],$$

for the volume current density J and for wires of radus b small compared with the other dimensions of the circuit.

From the tables of definite integrals

$$\int_0^{2\pi} d\phi' \ln(\zeta^2 + \zeta'^2 - 2\zeta\zeta'\cos\phi') = 2\pi \ln\left[(\zeta^2 + \zeta'^2 + \sqrt{(\zeta^2 + \zeta'^2)^2 - 4\zeta^2\zeta'^2})/2\right] = 4\pi \begin{cases} \ln\zeta & \text{for} \quad \zeta \geq \zeta', \\ \ln\zeta' & \text{for} \quad \zeta \leq \zeta'. \end{cases} \tag{10.15}$$

Substituting Eq.(10.15) into (10.14) and integrating yields

$$F_S = I^2/2, \tag{10.16}$$

where $I = \pi b^2 J$.

Carrying out the integrations for the y component of the Ampere forces between portions of the network not in contact, using Eq.(10.1), and combining the results with Eqs. (10.13) and (10.16) then gives the net force on the Ampere bridge according to Ampere's force law, Eq.(10.11), in exact closed form as

$$F_A(\text{bridge})/2I^2 = -3/4 + \ln 2 + \sqrt{1 + L^2/M^2} - \ln\left(1 + \sqrt{1 + L^2/M^2}\right) + \ln(L/b), \tag{10.17}$$

It may be similarly shown that the alternative F. E. Neumann force, Eq.(10.7), on the bridge is given by

$$F_N(\text{bridge})/2I^2 = -5/4 + \sqrt{1+L^2/M^2} - \ln(1 + \sqrt{1 + L^2/M^2}) - \ln 2 + \ln(1 + \sqrt{1 + L^2/M\text{-}N)^2}) + \ln(1 + \sqrt{1 + L^2/N^2}) - \ln(L/b). \tag{10.18}$$

## 10.4 Force on Ampere's Bridge Predicted by the Grassmann-Biot-Savart Law

Since orthodox electrodynamics claims the Grassmann-Biot-Savart law, Eq.(10.4), as the only empirically correct law for the force between the current elements; it is important to consider the Grassmann-Biot-Savart force on the Ampere bridge to reveal its absurdity (Wesley 1983a).

According to the Grassmann-Biot-Savart law (10.4) the force on a current element acts perpendicularly to the element: so considering Fig. 10.2, the net force acting on the bridge (sections 3, 4, and 5) that acts in the y direction must act only on section 4. Assuming wires thin in comparison to the other dimensions of the



bridge, the approximation using linear current elements, Eq.(10.4), may be used. The force on section 4 due to 1, 2, and 6 may be readily computed in closed form using elementary integrals to obtain

$$F_G(\text{bridge})/2I^2 = -1 + \sqrt{1 + L^2/M^2} - \ln(1 + \sqrt{1 + L^2/M^2}) + \ln(1 + \sqrt{1 + L^2/(M-N)^2}). \tag{10.19}$$

For the special case where the length of the bridge L is small compared with the side of the circuit M or the legs of the bridge M - N the Grassmann-Biot-Savart law goes to zero; thus,

$$F_G(\text{bridge})/2I^2 = 0 \quad \text{for} \quad L \ll M - N. \tag{10.20}$$

In contrast the Ampere force on the bridge for this special case remains large. In particular, for $b < L \ll M$ the Ampere force from Eq.(10.17) becomes

$$F_A(\text{bridge})/2I^2 = 1/4 + \ln(L/b). \tag{10.21}$$

Similarly the F. E. Neumann force for this case remains large, but is in precisely the opposite direction to the Ampere force, indicating a force of attraction: thus, from Eq.(10.18) for $b < L \ll M - N$

$$F_N(\text{bridge})/2I^2 = -1/4 - \ln(L/b). \tag{10.22}$$

The experimental results (as discussed below) reveal a large nonvanishing repulsive force, verifying Ampere's force law (10.17) and not the small to zero force predicted by the Grassmann-Biot-Savart force (10.19) nor the force of attraction predicted by the F. E. Neumann force (10.19) or (10.22).

In addition the Grassmann-Biot-Savart law does not provide a unique prediction. By changing the arbitrary labels, so that N becomes M - N and M - N becomes N, which should not alter the physics, the force predicted by Eq.(10.19) becomes

$$F'_G(\text{bridge})/2I^2 = -1 + \sqrt{1 + L^2/M^2} - \ln(1 + \sqrt{1 + L^2/M^2}) + \ln(1 + \sqrt{1 + L^2/N^2}), \tag{10.23}$$

which is not equal to Eq.(10.19). A valid physical law cannot give two different predictions. A valid physical law must yield a unique prediction. The Grassmann-Biot-Savart law is clearly absurd.

Accepting the labeling yielding Eq.(10.19) then yields the negative

of Eq.(10. 23) as the reaction force on the remainder of the circuit, sections 1, 2, and 6. Adding the negative of Eq.(10.23) to (10.19) yields the net force acting on the entire closed current loop given by

$$F_G(\text{loop})/2I^2 = ln(1 + \sqrt{1 + L^2/(M-N)^2}) - ln(1 + \sqrt{1 + L^2/N^2}), \quad (10.24)$$

which is nonzero, as would be required by Newton's third law. Thus, according to the Grassmann-Biot-Savart law this force could be used to drive a vehicle or raise a space craft without the need to expend any energy. And by simply changing the labels M - N to N the force could be made to act in the opposite direction. The Grassmann-Biot-Savart law is again seen to be obviously *absurd*!

## 10.5 Maxwell's Beliefs Concerning Ampere's Force Law

According to modern textbooks and most physicists, orthodox electrodynamics, which is limited to the Grassmann-Biot-Savart law and the Maxwell field equations, is supposed to be empirically correct and complete. Ampere's original (1823) force law (10.1) is not even mentioned in modern textbooks and in present-day literature and is known to few physicists. Since the erroneous beliefs inherent in so much of orthodox electrodynamics can be traced to Maxwell; it is of some interest to examine Maxwell's own beliefs concerning Ampere's orginal force law.

In his book, article 528, Maxwell (1891) praises Ampere as the "Newton of electricity". And concerning Ampere's theory, Maxwell says, "It is perfect in form, and unassailable in accuracy; and it is summed up in a formula (Ampere's law (10.1)) from which all phenomena may be deduced, and which must always remain as the cardinal formula of electrodynamics." Yet in the same article Maxwell complains that the evidence Ampere presents does not seem to yield his (Ampere's) force law: " . . . he (Ampere) discovered the (his) law by some process which he has not shown us . . . ".

(I have also wondered how and why Ampere chose his particular force law (10.1) from apparently insufficient quantitative evidence then available - especially, as his law seems to be, in fact, empirically correct, as discussed below.)

In article 687 of his book Maxwell derives the Ampere expression



(10.21) for the force on Ampere's bridge for the case L << M by considering the force necessary to change the energy of self inductance in a current loop for M → ∞ when M is increased by an element of distance δM (see Fig. 10.2), which yields the longitudinal force or positive tension between the wire portions neighboring δM. Since the theory of inductance is compatible with the F. E. Neumann theory, which yields the same result as Ampere's law for closed current loops; it is not surprizing that Maxwell's derivation agrees with Ampere's law for this case. Maxwell speaks of this force, Eq.(10.21) as a "tension", which implies the acceptance of a longitudinal force between colinear current elements. Yet Maxwell writes in the same article: "This experiment (the Ampere bridge experiment) is sometimes adduced to prove that two elements of current in the same straight line repel each one another; and thus to show that Ampere's formula, which indicates such a repulsion of colinear current elements, is more correct than that of Grassmann, which gives no action between two elements in the same straight line. But it is manifest that, since the formulas of both Ampere and Grassmann give the same results for closed circuits, and since we have in the experiment only a closed circuit, no result of the experiment can favor one more than the other of these theories."

But, contrary to these assertions by Maxwell, the Grassmann-Biot-Savart law yields a zero force on Ampere's bridge for L << M - N, as given by Eq.(10.20), quite independent of the radius of the wire b, which is quite different from the nonzero force predicted by the Ampere law, Eq(10.21) for this case. Since it is such a trivial matter to obtain the Grassmann-Biot-Savart result for this force on Ampere's bridge, Eqs.(10.19) and (10.20), (in comparison to the involved mathematics necessary for Maxwell's round-about method of deriving the Ampere force on the bridge for this case, Eq(10.21)); one may suspect that Maxwell is being dishonest, when he makes his obviously false claim that the Grassmann-Biot-Savart law yields the same result as the Ampere law. Moreover, since the Grassmann-Biot-Savart law can act only transversely on a current element, as Maxwell himself states; it is trivially obvious that the Grassmann-Biot-Savart force on the bridge must go to zero as L goes to zero, quite independent of the radius of the wire b, which

is not the same as the Ampere result (10.21).

In Articles 509, 510, and elsewhere in his book Maxwell claims, like Grassmann (1845), that only closed rigid current loops can exist and that thus isolated current elements are impossible. Again it is hard to believe that Maxwell could have been so ignorant of the relationship between electrostatic charge and currents, as evident by the great success of Weber's potential, Eq.(4.5), the Faraday law of electrochemical deposition, and the currents necessary to charge and discharge condenser plates and Faraday's cup. Obviously charges can flow out and back along a straight wire to form an electric dipole antenna without a closed current loop being involved. And obviously individual isolated charges can move as isolated current elements. Again it would seem that Maxwell may have been dishonest in his support of the Grassmann-Biot-Savart law, perhaps to justify his field theory.

In article 687 of his book Maxwell claims (as already quoted above) that the Ampere and Grassmann forces on the Ampere Bridge must be the same; as "only a closed circuit" is involved and the Ampere and the Grassman laws yield the same result for the net force between two closed mechanically rigid current loops. This is a most amazing non sequitur! In the Ampere bridge experiment only the *one* closed current loop is involved and not the *two* closed current loops necessary for the equivalence of the Ampere and Grassmann laws. Moreover, it is totally irrelevant if a closed current loop is involved or not; as it is only a question of the analysis of the mechanical forces between two objects, the wire bridge and the remainder of the circuit as a mechanical object. The Grassmann derivation of his law from Ampere's law is only valid if the net longitudinal mechanical force in the wire and in the direction of the current, as predicted by Ampere's law, add up to zero around the closed loop. This is only possible if the closed loop is mechanically rigid. This means, according to Grassmann's derivation that the net force between two mechanicaly rigid closed current loops cannot reveal the logitudinal component of the force acting on a current element. This also means that the Grassmann law cannot be equivalent to the Ampere law when the loops are not mechanically rigid in their entirety. The current loop in the Ampere bridge



is not mechanically rigid in its entirety; thus, the Ampere law and the Grassmann law cannot be equivalent in this case, as apparent from Eqs.(10.1), (10.4), (10.17), and (10.19).

Maxwell also cavalierly neglects the need to satisfy Newton's third law for the force betwen two current elements. Newton's third law *must* be satisfied for the force between two moving charges, and thus between two current elements; as already recognized by Weber (1846, 1848, and 1893).

## 10.6 Other Demonstrations of the Ampere Repulsion Between Colinear Current Elements

The Ampere repulsion between colinear current elements has been demonstrated in a number of ways in addition to the Ampere bridge experiment. Although these demonstrations indicate that an Ampere repulsion exists and indicate an order of magnitude of the force involved; they are not suited to establish the Ampere repulsion between colinear current elements precisely quantitatively.

10.6a Rupturing of current carrying wires - Nasilowski (1964, 1984) observed the rupturing of copper wires when loaded with large currents. The wires were fragmented. The fractured ends were broken perpendicularly to the length of the wires, indicating a tensile fracture in a brittle material. Nasilowski's observations were confirmed by Graneau (1983, 1984a). Graneau and Graneau (1985) also observed the rupturing of current carrying liquids. The Ampere repulsion between colinear current elements is the only force available to account for the rupturing; and the Ampere force involved is sufficiently large to account for the effect.

10.6b Propulsion of the Hering-Graneau submarine - Hering (1923) and Graneau (1982) found that a wedge shaped piece of copper when placed in current carrying mercury is propelled with the broad end forward in the direction of the current, but independent of the sense of the current flow.

Considering the force on Ampere's bridge, Eq.(10.17), the force on the copper wedge may be viewed as due to a difference in a force on a wire of radius b(wide) and the force on a wire of radius

b(small), everything else being equivalent, which then yields

$$F_S = 2I^2 ln\left[b(\text{large end})/b(\text{small end})\right], \qquad (10.25)$$

in the direction of the current in either sense with the broad end forward. It is apparent that the b's in this formula may be also chosen as simply the areas of the ends of the wedge, independent of their shape. Thus the Ampere repulsion between colinear current elements is sufficient to account for the phenomenon; even though precise quantitative measurments may not be possible.

10.6c The Hering pump - Northrup(1907) performed an experiment involving Hering's pump. Mercury is contained in a vessel that is narrower at the bottom of radius b(small) and wider at the top of radius b(large). When current flows up or down through the vessel the mercury is driven upward against the force of gravity. According to the theory developed by Wesley (1992), the force is primarily due to the Ampere repulsion between colinear current elements, as given by Eq.(10.25). An order of magnitude agreement between the Wesley theory and the Northrup experiment is obtained; although no precise quantitative test of the Ampere force between colinear current elements is possible.

10.6d Phipps' oscillating wedge - Phipps, Jr. (1990) and Phipps and Phipps, Jr. (1990) observed the oscillations in a mercury wedge carrying a slowly oscillating current, as measured by the heights of two mercury columns at either end of the wedge. The net force to displace the mercury upward in the column at the wider end of the wedge relative to the column at the smaller end of the wedge is agian given by Eq.(10.25). Satisfactory approximate agreement between theory and experiment was obtained. But again no precise quantitative empirical confirmation of the Ampere repulsion between colinear current elements could be established.

10.6e The Graneau-Phipps-Roscoe jumping armature experiment - Graneau, Phipps, and Roscoe (2001) performed an experiment in which a small copper cylinder armature is suspended vertically between two gaps, the upper gap being larger than the lower gap. When current is fed through the armature by sparking across the gaps, the armature jumps upward a height proportional to the impulsive force given



to the armature.

The current in the large gap above the armature is spread over a wide diameter, b(large), proportioanl to the gap width; while the current in the small gap below the armature is spread over a small diameter, b(small), proportional to the small gap width. Thus, the force driving the armature upward should be given approximately by the Ampere force between colinear current elements, as given by Eq.(10.25). The Ampere force between colinear current elements is thus qualitatively sufficient to account for the observations. No precise quantitative check on the Ampere theory is possible.

## 10.7 Analysis of the Moyssides-Pappas Experiment

Although it is apparent from the many repetitions of the Ampere bridge experiment and from the other experiments briefly reviewed in the previous Section 10.6 that a repulsive force between colinear current elemnets does, in fact, exist; the precise quantitative magnitude of this force has remained uncertain. The evidence provided by the force between two closed rigid current loops, that satisfy Newton's third law, as given by Eq.(10.17) or (10.18), is arbitrary to within at least the $\alpha$ parameter in Eq.(10.8).

One of the obstacles to obtaining precise quantitative results has been the lack of an exact expression for the Ampere force on Ampere's bridge with wires of circular cross section, as now given here by Eq(10.17) for the first time.

The most adequate quantitative measurement of the force on Ampere's bridge that permits a comparison with the theory Eq.(10.17) is provided by the Moyssides-Pappas (1986) experiment.

10.7a Description of the Moyssides-Pappas experiment - The experimental setup is indicated in Fig. 10.3. The $\Pi$ shaped Ampere bridge made of wire with a circular cross section of radius b, of width L = 48 cm and legs M - N = 77 cm long is suspended horizontally by 3 m long fibers. The ends of the bridge make contact with mercury cups, which are connected through leads N = 43cm long to a source of current, that is maintained constant, despite any changes in the wire temperature or other causes, during the measurement, lasting no

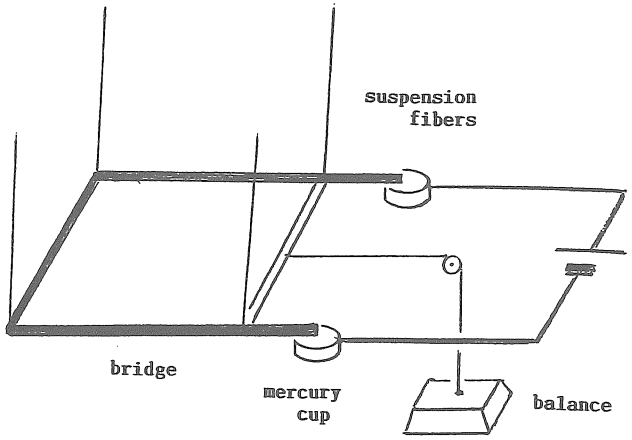



Fig. 10.3 Diagram of the Moyssides-Pappas setup.

more than about 7 seconds. A rod of insulating material holds the legs of the bridge rigidly apart. A horizontal fiber passed from the rod over a pulley is attached to an electronic balance that measures the force on the bridge when current flows.

To eliminate the effect of the Earth's magnetic field the mean force for two opposite directions of the current I were used. The effect of friction was determined by measuring the force as a function of $I^2$ and extrapolating to zero current, the displacement of the curve downward yielding the force to overcome friction, which was then added to the readings. The balance with the bridge was calibrated by placing known weights on the balance.

To eliminate the effect of the singularity force bridges with ends bent 90° outward 1 and 2 cm were also used. For these bridges the observed force on the bridges were found to be independent of the radius b of the wire used; as expected from the theory, the singularity forces produced by adjacent colinear current elements, being in opposite directions, cancelling.

10.7b Results of the Moyssides-Pappas experiment – The result for the force on the bridge with straight ends, where L = 48 cm and M = 120 cm, as a function of the radius b of the wire is shown, as points, in Fig. 10.4. The solid curve presents the theoretical



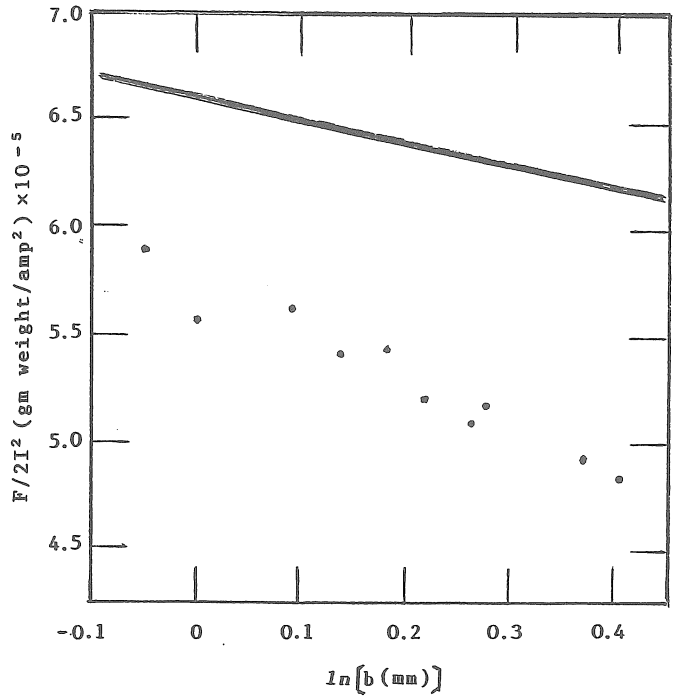



Fig. 10.4 The force, as $F/2I^2$ in gm weight/amp$^2$ $\times 10^{-5}$, on Ampere's bridge observed by Mossides and Pappas (as points) as a function of the logarithm of the radius of the wire b in mm compared with the Ampere theory (solid curve) as given by the exact expression for the Moyssides-Pappas case, Eq.(10.26).

prediction given by Ampere's law Eq.(10.17) for the Moyssides-Pappas setup, Eq.(10.26) below.

The experimental points may be fitted by an approximate straight line given by

$$F/2I^2 = (5.72 - 2.25\, ln\, b) \times 10^{-5}, \qquad (10.25)$$

where F is the force in gram weight, I is the current in amperes, and b is the radius of the wire in millimeters. From the spread

of the points in Fig. 10.4 the constant term in Eq.(10.25) becomes $5.72 \pm 0.20$ gm weight/amp$^2$ $\times 10^{-5}$, which is an experimental error of 3%. The coefficient of the logarithm term becomes $2.25 \pm 0.50$ for an experimental error of 22% for this coefficient.

10.7c Comparison of the Moyssides-Pappas results with the Ampere theory - The exact expression for the Ampere force on Ampere's bridge Eq.(10.17) for the Moyssides - Pappas case becomes

$$F_A/2I^2 = (6.60 - 1.02\, ln\, b) \text{ in gm weight/amp}^2 \times 10^{-5}. \qquad (10.26)$$

For the largest force measured for a small radius b the observed value is 12% less than the theoretical value, As the force decreases the discrepancy increases to 22% at the smallest force observed. All of these discrepancies are greater than the experimental error.

Assuming the Ampere theory is correct, systematic errors are apparently involved that cause a greater decrease in the force with the radius b. Since a material junction is involved between the copper wire of the bridge and the mercury in the cup; a negative tension might arise, when current flows, that increases with the area of the interface. In order to investigate this possibility wires of different metals could be investigated.

The bridge, as indicated in Fig. 10.3, was displaced horizontally a different distance for different forces on the bridge, which may have introduced a systematic error. Sufficient weight should have been added to the balance to return the bridge back to its original position for all readings. The electronic balance should have, thus, been used as merely a null indicator, the added weight on the balance being a measure of the force acting.

An investigation involving different choices for the dimensions of the bridge and the external network, involving different values of L, M, and N, would permit further checks on Ampere's force law and might reveal sources of systematic errors.

In any case, the Moyssides-Pappas experiment verifies the Ampere force law quantitatively to at least an accuracy of 15%, the observed forces being less than the theoretical by this amount.

Considering the milliards of dollars per year spent for physics research, it seems strange that one of the most fundamental and important of all physics laws, Ampere's original force law, has still



not been experimentally validated precisely.

10.7d The Moyssides-Pappas results involving bridges with bent ends - Moyssides and Pappas also investigated the force on Ampere's bridge when the wire ends of the bridge were bent outward at right angles; so the singularity force on one leg cancelled the singularity force on the other leg.

The theoretical force on a bridge with bent ends may be readily computed from Ampere's force law (10.1) in closed form using elementary integrals (Wesley 1987b). The results are shown in Table 10.1

Table 10.1 Force on Ampere's bridge as $F/2I^2$ in gm weight/amp$^2$ $\times 10^{-5}$

| length of bent ends | observed | Ampere theory |
|---|---|---|
| 1 cm | $3.52 \pm 0.07$ | 4.75 |
| 2 cm | $3.03 \pm 0.06$ | 4.51 |

For this case of bridges with bent ends the observed forces are about 26% and 33% less than the theoretical values, which seems to indicate that systematic errors are involved in the determination of the forces.

7.10e Possible alternatives to Ampere's law satisfying Newton's third law - It is of interest to see if the Moyssides-Pappas results yield an empirically superior force law to the Ampere force law, that also satisfies Newton's third law, as given by Eq.(10.8) for any arbitary $\alpha$. In particular, the value of $\alpha$ is given by

$$\alpha = \left[F(\text{observed}) - F_A\right]/(F_N - F_A), \qquad (10.27)$$

where the F's now refer to the force on Ampere's bridge.

For the Moyssides-Pappas setup the force $F_N$ may be computed from Eq.(10.18), yielding

$$F_N/2I^2 = -6.19 + 1.02\, ln\, b, \qquad (10.28)$$

in gm weight/amp$^2$ $\times 10^{-5}$ and b is in mm.

The value of $\alpha$ to obtain the best fit with the theory, Eq.(10.8), for the magnitude of the force when b = 1 mm, so $ln\left[b(mm)\right] = 0$, may be considered. Thus, from Eqs.(10.27), (10.28), and (10.26) for this case the appropriate value of $\alpha$ becomes

$$\alpha\,(\text{to fit magnitude of the force}) = 0.07. \tag{10.29}$$

To fit the observed slope of the force as a function of $ln\,b$ the value of $\alpha$ from Eqs.(10.27), (10.28), and (10.26) would have to be

$$\alpha = (\text{slope observed} - \text{slope Ampere})/(\text{slope Neumann} - \text{slope Ampere}) = 0.60\,. \tag{10.30}$$

But this value of $\alpha$ to fit the slope is not acceptable. It is too large; as it would yield a force of attraction on the bridge and not the observed repulsion.

Considering the errors in the observations the $\alpha$ chosen to fit the magnitude of the force, Eq.(10.29), is too small to be significant. It seems that $\alpha$ should be chosen as zero; so the Ampere force law alone is sufficient.

The Moyssides-Pappas experimental results prove that the F. E. Neumann force all by itself is not valid for the force between two current elements; because it predicts a force of attraction on the Ampere bridge, Eq.(10.28), instead of the observed repulsion. However, the F. E. Neumann force remains valid for the force between two entire closed rigid current loops.

Since the Ampere force all by itself yields both the force between two current elements (as verified by the Moyssides-Pappas experiment to about 15%) as well as the force between two entire closed rigid current loops; it may be concluded that the Ampere force all by itself, Eq.(10.1), is the correct law for the force between two current elements.

10.7f The Grassmann-Biot-Savart force on Ampere's bridge for the Moyssides-Pappas case - The Grassmann-Biot-Savart force on the Ampere bridge for the Moyssides-Pappas experiment may be obtained from Eq.(10.19) for L = 48 cm, M = 120 cm, and N = 43 cm, yielding

$$F_G(\text{bridge})/2I^2 = 0.125 \text{ gm weight/amp}^2 \times 10^{-5}\,, \tag{10.31}$$



which is 1/46th the observed force. In addition, it is not a function of the radius of the wire b, which is also not in agreement with the observations.

To make the absurdity of the Grassmann-Biot-Savart law even clearer the force on the lower fixed portion of the circuit may be obtained by replacing M - N by N and reversing the sign in Eq.(10.19), yielding the reaction force as

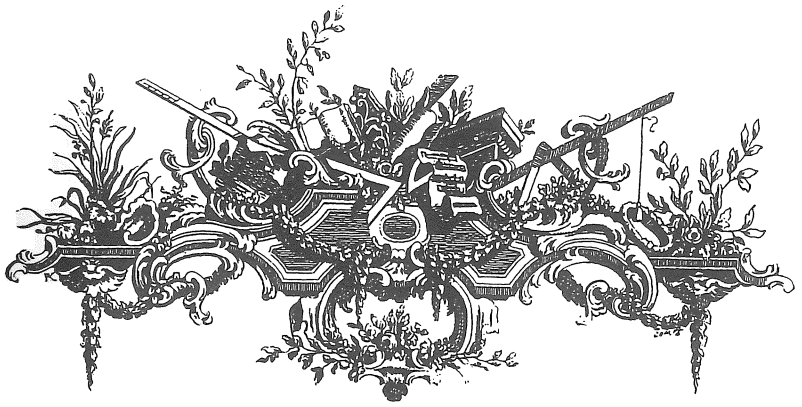
$$F_G(\text{reaction})/2I^2 = -0.262 \text{ gm weight/amp}^2 \times 10^{-5}\,. \tag{10.32}$$

which is 1/22nd of the observed force on the bridge. And, moreover, this force, Eq.(10.32) is not the negative of the force acting on the bridge, Eq.(10.31); so Newton's third law is violated.

The net force on the entire circuit, the bridge and the remainder of the circuit, as given by adding Eqs.(10.31) and (10.32) is

$$F_G(\text{loop})/2I^2 = -0.137 \text{ gm weight/amp}^2 \times 10^{-5}\,. \tag{10.33}$$

This force, Eq.(10.33), could then be used to do work without the need to expend any energy. The complete absurdity of the Grassmann-Biot-Savart law is thereby demonstrated for the particular Moyssides-Pappas case.



CHAPTER 11

# SCIENTIFIC QUANTUM THEORY

Traditional orthodox Copenhagen quantum mechanics is often cited as the worst example of schizophrenia in modern physics. Considering the numerous antiscientific mystical beliefs that it embodies, this claim may be justified. For example, one is supposed to believe: Nonobserved particles and states do not exist. A single point particle is supposed to pass through two widely separated slits simultaneously. Thoughts are supposed to affect experimental results - *psychokinesis*. Pure mathematical superposition is supposed to mean physical causality. Local "observables" are *defined* as smeared out integral averages taken over all space. *Causes* are supposed to be able to produce instantaneous widely distant *effects* without any physical mechanism required - like *astrology*. A point particle is supposed to be a huge "*wave packet*" smeared out over all space, that can never be detected, because it "*collapses*" to a point particle upon any attempt to observe it. Observations are supposed to be limited in accuracy by huge "*uncertainties*" prescribed by the "*uncertainty principle*"; even though actual observations are many orders of magnitude more precise. A quantum particle is not supposed to have a *phase*, a phase that is necessary to predict interference phenomena. *All physics* is supposed to be prescribed by an arbitrary *operator approach* yielding an eigenfunction-eigenvalue problem. The orthodox quantum mechanics is supposed to yield not only wave effects but also classical mechanics in the large; but quantum mechanics produces large scale effects that cannot be predicted by classical mechanics, such as a particle diverted many kilometers from its would-be trajectory due to interference. The imaginary number $i = \sqrt{-1}$ is supposed to be accepted in orthodox quantum



mechanical laws without any prescription of how to find the real and imaginary parts to compare with experimental observations. Physical quantities are not supposed to have any precise values; they are supposed to exist as "intrinsic probabilities" involving "probability amplitudes". The tunnelling of a particle through a potential barrier is supposed to be explained by violating the conservation of energy. A *single* localized quantum particle is supposed to be a *wave* spread out over all space - "*wave-particle duality*". A *point* particle is supposed to then be able to interfere with itself! Two quantum particles, distinguishable by being at two different locations, are supposed to be "*indistinguishable*". Time is supposed to enter into the orthodox theory *only* as $\exp(-iEt/\hbar)$, where E is the constant total energy; consequently all "*observables*", defined as "*expectation values*", being time independent, are not supposed to vary with time. The electron in the hydrogen atom is not supposed to move; but it is supposed to have "*orbital angular momentum*". The de Broglie wave for slowly moving particles is supposed to have an *infinite wave velocity* when the particle itself comes to rest. (Wesley 1961, 1965, 1983c, 1984, 1987, 1991t, 1995, 1996i, 1999b).

For some current mystical ideas in the orthodox quantum mechanics a paper by Costa de Beauregard (2001) provides many relevant *references*.

Despite all of the pseudoscience and mysticism of the orthodox quantum mechanics, there are some very real quantum phenomena that need to be explained by a sensible scientific quantum theory. This Chapter 11 is devoted to presenting some realistic scientific quantum theory to explain some of the observed quantum phenomena. Needless-to-say, there are questions that remain without any adequate scientific answers.

## 11.1 Newton's Quantum Theory for Light

Newton (1730), as others in his day, regarded classical mechanics as the most fundamental of all sciences. He also accepted the ancient Greek atomists idea that all substances were composed of particles, or "atoms". Thus, it is not surprizing that Newton regarded light as a flux of corpuscles, particles, or photons, obeying the laws of classical mechanics.

At the same time Newton was also well aware of the wave or periodic nature of light. He was, in fact, the first person to *measure* the wavelength of light. He observed the colored interference rings (Newton's rings) produced in a film of air trapped between a plano convex lens and a flat glass surface, when light was normally incident. From the geometry of his setup he was able to deduce the wavelength (equal to twice the distance between his "fits") appropriate for the different colors.

Huygens (1690) is generally credited today with championing the wave theory of light in opposition to Newton's corpuscular or photon theory. But this is not quite correct; as Huygens' view of a "wave" was that of a shock wave devoid of any periodic character; while Newton was aware of the periodic or true wave nature of light.

Following Thomas Young (1802, 1804) with his double pinhole interference experiment and Fresnel's (1826) many experiments so satisfactorily predicted by the wave theory for light, it became popular to claim that Newton was wrong with his photon theory of light. Modern textbooks (eg., Jenkins and White 1957) in introductory physical optics still claim or imply that the wave theory is incompatible with the photon theory; so Newton was wrong. Young himself did not feel that Newton was wrong. Young used Newton's values for the wavelength of light to obtain his observed fringe pattern. Young did not feel that the superposition of waves, or wave theory, precludes the particle theory for light. In fact, the wave theory and the particle flux theory, or hydrodynamic theory, are mathematically completely compatible (as revealed below in Section 11.4) in agreement with Newton and Young. The wave theory and the particle flux, or hydrodynamic, theory are merely two mathematically isomorphic representations of precisely the same physical phenomenon.

## 11.2 Erroneous Classical Explanation of Double Pinhole Interference Produced the Wave-Particle Problem

The wave-particle problem arose after Young's (1802, 1804) double pinhole experiment seemed to reveal the impossibility for particles to yield the observed interference pattern. Young, applying Newton's observation of the superposition of waves on water to light, was able to apparently explain the observed pattern as a superposition of



light waves proceeding from the two pinholes arriving at a point on the screen apparently causing the observed intensity on the screen, as indicated in Fig. 11.1.

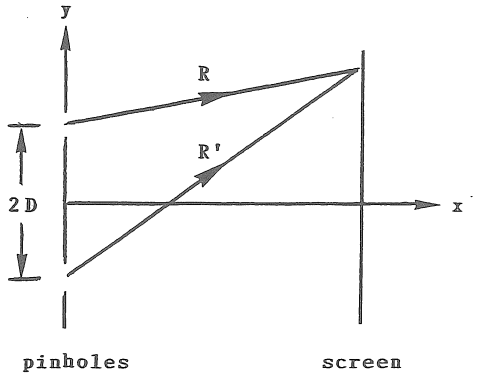



Fig. 11.1 Diagram for the Young's double pinhole experiment.

In particular, if $\psi$ and $\psi'$ are the component waves, then the resultant wave at the point of observation for plane waves is

$$\Psi = \psi + \psi' = A\sin(kR - \omega t) + A\sin(kR' - \omega t), \tag{11.1}$$

where

$$R^2 = x^2 + (y - D)^2, \qquad R'^2 = x^2 + (y + D)^2, \tag{11.2}$$

where the distance between the pinholes is 2D and where A is the amplitude of the component waves, $k = 2\pi/\lambda$ is the propagation constant and $\lambda$ the wavelength, and $\omega = 2\pi f$ is the angular frequency.

For the screen at x far from the pinholes the component waves may be approximated as plane waves, which then yields the wave incident on the screen as

$$\Psi = 2A\sin\left[k(R+R')/2 - \omega t\right]\cos\left[k(R-R')/2\right]. \tag{11.3}$$

The intensity of the wave registered on the screen then becomes

$$I = \langle \Psi^2 \rangle_t = 4A^2\cos^2\left[k(R - R')/2\right]. \tag{11.4}$$

For x large Eqs.(11.2) yield

$$R - R' = 2Dy/x; \tag{11.5}$$

so the maxima occur at

$$R - R' = n\pi, \quad \text{or} \quad y(\max) = (\pi x/2kD)n; \tag{11.6}$$

and the minima at

$$k(R - R') = (n + 1/2)\pi, \quad \text{or} \quad y(\min) = (\pi x/2kD)(n + 1/2). \tag{11.7}$$

In terms of the wavelength $\lambda = 2\pi/k$ Eqs.(11.6) and (11.7) become

$$y(\max) = (\lambda x/4D)n, \qquad y(\min) = (\lambda x/8D)(2n + 1). \tag{11.8}$$

1.2a The energy flux is observed and not the "intensity" - The above traditional classical explanation for the double pinhole interference is not correct. This impossible explanation, that is supposed to characterize wave behavior in general, has given rise to the wave-particle problem, whose trivial resolution (Wesley 1961, 1965, 1983d, 1984, 1988, 1991t, 1996h) continues to be ignored. The most serious difficulty with the orthodox Copenhagen quantum mechanics resides in the 200 year old false interpretation of the Young double pinhole experiment.

In order for light to be detected it must be absorbed. Thus, the interference pattern on the screen can only be observed if energy is continuously supplied to the bright fringes. It is, thus, the light energy flux that is observed, as given by the Poynting vector, and not the "intensity". The "intensity" of a light wave is a stationary nonpropagating feature of the wave. It is ordinarily not observed.

In particular, light may be represented as a scalar wave. The vector properties of a light wave may be obtained by considering two simultaneous scalar waves, each with precisely the same propagation properties (Wesley 1983i). The energy flux $\mathbf{S}$ and energy density $E$ may then be given by

$$\begin{aligned} \mathbf{S} &= -\nabla\Psi\,\partial\Psi/\partial t, \\ E &= (\nabla\Psi)^2/2 + (\partial\Psi/\partial tc)^2/2, \end{aligned} \tag{11.9}$$

where $\Psi$ is a solution to the homogeneous wave equation,

$$\nabla^2\Psi - \partial^2\Psi/\partial t^2c^2 = 0, \tag{11.10}$$

subject to appropriate boundary conditions, where an amplitude factor may be appropriately chosen to yield an *energy* flux for $\mathbf{S}$.

Substituting Eq.(11.1) for the double pinhole case into



Eqs.(11.9), the correct observed energy flux and the energy density for the case of the screen far from the pinholes are given by

$$\begin{aligned} \mathbf{S} &= \omega kA^2\left[\cos(kR - \omega t) + \cos(kR' - \omega t)\right]^2, \\ E &= k^2A^2\left[\cos(kR - \omega t) + \cos(kR' - \omega t)\right]^2, \end{aligned} \tag{11.11}$$

where $k = \omega^2/c^2$.

Only the steady state time average energy flux and density are of interest for the double pinhole example. Averaging over a cycle, then yields

$$\begin{aligned} \langle \mathbf{S} \rangle_t &= 2\omega kA^2\cos^2\left[k(R - R')/2\right], \\ \langle E \rangle_t &= 2k^2A^2\cos^2\left[k(R - R')/2\right]. \end{aligned} \tag{11.12}$$

Thus, neglecting the spherical nature of the waves in the asymptotic region, the mean velocity of energy propagation of light onto the screen is given by

$$\bar{w} = \langle \mathbf{S} \rangle_t / \langle E \rangle_t = \omega k/k = ck/k = c, \tag{11.13}$$

the velocity of light.

It might be argued that, since the same interference pattern is given by the fictitious "intensity", Eq.(11.4), as by the time-average Poynting's vector, the first of Eqs.(11.12), it is a matter of indifference whether Eq.(11.4) or (11.12) is used. But this is not correct. Only a proper physical quantity, the Poynting vector, the first of Eqs.(11.12), should be used to predict actual physical results. The fictitious mathematical "intensity" implies that arbitrary nonphyiscal quantities that yield the same prediction are also admissible. But this is not proper empirical science. An "intensity" that somehow just exists on the screen without any energy transmission being necessary is "spooky" physics. The crowing of the rooster to predict the rising of the sun is not as good an explanation as the rotation of the Earth.

11.2b The "superposition paradox" - The traditional classical explanation for the double pihole interference pattern, presented above in Section 11.2, is impossible; because *nothing* physical can travel from *both* pinholes to a bright fringe on the screen. The

two component mathematical wave functions, $\psi$ and $\psi'$, travelling from the two pinholes along straight lines to a point of observation on the screen, are mathematical fictions, representing nothing directly physical. The component wave functions are merely mathematical generating functions, that, when added, yield the true physical sum wave $\Psi$, as given by Eq.(11.3).

In particular, the first of Eqs.(11.6) and (11.7) define sets of nested hyperbolic surfaces (rotated about the y axis) with foci at the pinholes at $x = 0$ and $y = \pm D$. The inner hyperbolic surfaces for smaller values of y are given by smaller values of the integer n. On the hyperbolic surface for $n = 0$, given by the first of Eqs.(11.7), no light is observed; it is a nodal surface. The maximum light is observed on the hyperbolic surfaces given by the first of Eqs.(11.6). A straight line drawn from the lower pinhole to a point on the upper half of the screen above the x axis, as shown in Fig. 11.1, must cross zero nodal surfaces before arriving at the screen. A physical effect, travelling along such a straight line, such as $\psi$ or $\psi'$, must cross surfaces where the effect is never observed. There is, thus, no evidence that *anything physical* proceeds along straight lines from each pinhole to arrive at a point of observation on the screen. On the contrary, the bright fringes can only be established by the energy travelling parallel to a hyperbolic surface.

The exact energy flow pattern through the two pinholes for spherical waves valid for all x is shown in Fig. 11.2 (Wesley 1983s).

It is obvious that physically the superposition of physically real component waves $\psi$ and $\psi'$ cannot account for the observed interference pattern - thus, the "*superposition paradox*".

An amusing example of the "superposition paradox" is the Schroedinger (1952) "cat in a box paradox". In answer to the orthodox quantum mechanics insistence that the superposition of two wave functions means the physical superposition of two physical states, Schroedinger considered a cat placed in a closed box containing a device that has a 50-50 chance of killing the cat during the course of an hour. According to the orthodox theory the cat, while in the box, is prepared in a state of being half alive and half dead. But, if, when the box is opened after an hour, the cat is found to be entirely alive, then the cat must have been alive



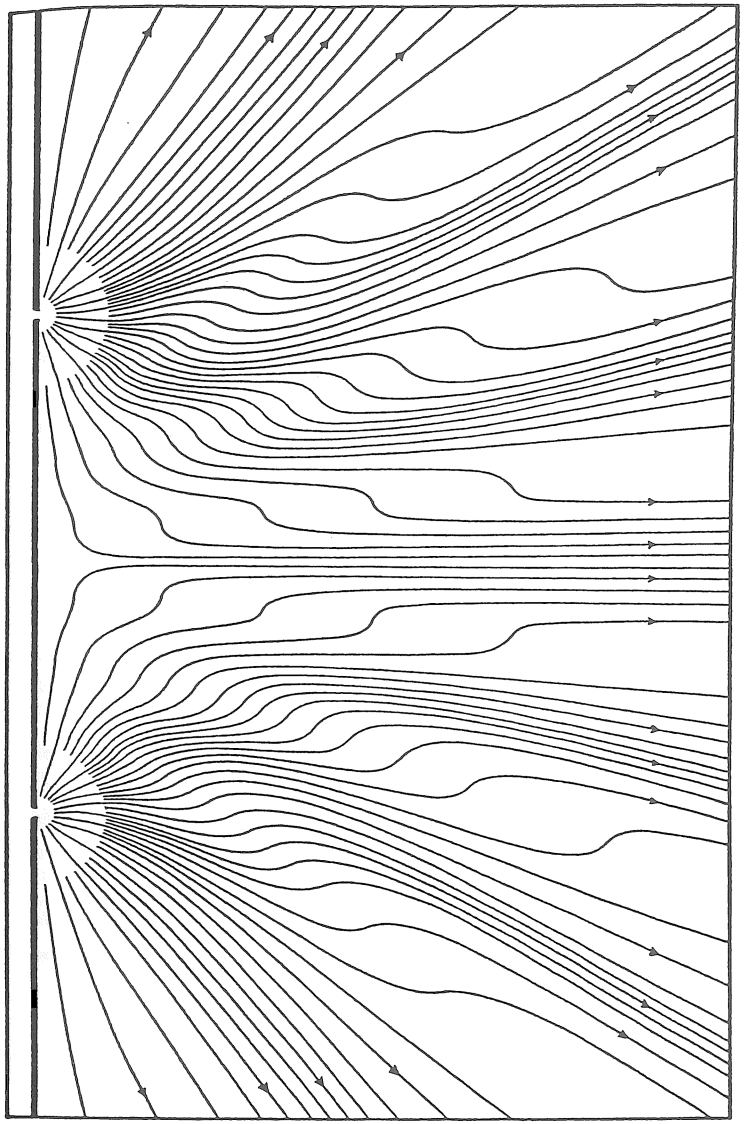


Fig. 11.2 Exact particle trajectories through double pinholes yielding interference, where the distance between pinholes is 3.6 times the wavelength, $2D = 3.6\lambda$ (Section 11.4b).

the whole time while in the box and not half alive and half dead. Trying to resolve the paradox, the orthodox theory, appealing to its own peculiar "measurement theory", claims the act of opening the box causes the half dead - half alive cat to "collapse" into a state of being entirely alive.

## 11.3 Resolution of the "Superposition Paradox"

From the discussion concerning Young's double pinhole interference in the previous Section 11.2 it is clear that the superposition of classical wave theory cannot represent physical causality. The presumed physically real component waves $\psi$ and $\psi'$ cannot be superposed to *cause* the observed "intensity" on the screen; since $\psi$ and $\psi'$ cannot exist *physically* at all points along the straight lines from the pinholes to the points of observation on the screen.

Empirically interference phenomena reveal only the energy flux, Eq.(11.9), or the Poynting vector (whose vector character can be represented by two simultaneous appropriately chosen scalar waves (Wesley, 1983i)).

The "superposition paradox" is resolved by simply attributing no physical causality to *superposition*. Superposition is merely a mathematical device or method used to represent a function by a series of component functions. A mathematical function represented by a Fourier series is not *caused* by the superposition of the component sinusoidal functions. A mathematical function represented by a series of Bessel functions is not *caused* by the superposition of the component Bessel functions. Etc.

The orthodox Copenhagen quantum mechanics involves all sorts of absurdities as a consequence of attributing causality to mathematical superposition. For example, component probability amplitudes, or wave functions, are supposed to superpose to *cause* a resultant probability amplitude. A particular quantum state is thus often viewed as a physical combination, mixture, or distribution over various component quantum states. Etc.

## 11.4 The Resolution of the Wave-Particle Problem

As indicated in Sections 11.2 and 11.3 above, the wave theory



must be viewed empirically as simply a mathematical device, or tool, to predict the energy flux. The traditional classical explanation for the Young double pinhole interference, based erroneously upon *causal* superposition, is not valid. However, when the wave theory is employed to derive the energy flux and density, as given by Eqs.(11.9), then it becomes a valid empirical theory.

It is generally recognized that individual particle fluxes moving in straight lines associated with each component wave cannot superpose to yield the observed resultant double pinhole interference pattern. Therefore, it has been erroneously believed that the interference of light proves that light must be a *wave* and not a *flux of particles* (as assumed by Newton). However, as explained above in Section 11.2b, the wave theory also does not permit superposition to be used as a proper physically causal explanation for the observed interference. Neither the wave theory nor the particle flux theory can be based upon superposition as a causal physical phenomenon. *Superposition is mathematics not physics* !

11.4a Particle flux yielding wave behavior - From the expression for the energy flux and energy density, Eqs.(11.9), of a *wave*, it is clear that a *particle flux* exhibiting the same energy flux and energy density will exhibit precisely the same physical properties as a *wave*, such as interference, reflection, or refraction at an interface (Wesley 1984). The Eqs.(11.9) may, thus, be interpreted as simply an alternative hydrodynamic representation of wave phenomena, that is completely mathematically isomorphic with the usual wave representation.

The particle velocity w transporting the energy with the energy flux S and density $E$, Eqs.(11.9), is then given by

$$w = S/E, \tag{11.14}$$

The motion of a quantum particle along discrete trajectories as an explicit function of time and the initial conditions may then be obtained by integrating the differential equations

$$dx/w_x = dy/w_y = dz/w_z = dt. \tag{11.15}$$

For a free plane propagating wave,

$$\Psi = A \sin(k \cdot r - \omega t), \tag{11.16}$$

the particle velocity from Eqs.(11.9), (11.14), and (11.16) becomes

$$w = 2k\omega A^2\cos^2(k\,r - \omega t)\Big/(k^2 + \omega^2/c^2)A^2\cos^2(k\,r - \omega t)$$
$$= k\omega/k^2 = c. \qquad (11.17)$$

The particle velocity of a free plane wave thus equals the phase velocity $c$ of the wave.

11.4b Exact particle flow yielding double pinhole interference - The asymptotic particle flow for x large for double pinhole interference has already been indicated by the first of Eqs.(11.6) for the maxima. The derivation of the exact particle flow for all x requires spherical waves emanating isotropically from the pinholes. In this case

$$\psi = (A/R)\sin(kR - \omega t) \quad \text{and} \quad \psi' = (A/R')\sin(kR' - \omega t), \qquad (11.18)$$

where $R$ and $R'$ are given by

$$R = xe_x + (y - D)e_y, \quad \text{and} \quad R' = xe_x + (y + D)e_y. \qquad (11.19)$$

where $e_x$ and $e_y$ are unit vectors in the x and y directions. From the cylindrical symmetry about the y axis it is sufficient to consider the xy plane only.

To agree with observations it is only necessary to consider the time average energy flux and energy density to obtain the time average particle velocity defined as

$$\bar{w} = \langle S\rangle_t / \langle E\rangle_t . \qquad (11.20)$$

Adding Eqs.(11.18), substituting into Eqs.(11.9), and taking a time average over a cycle yields

$$\langle S\rangle_t = (\omega A^2/2RR')\left\{(R/R^2)\left[kR' + kR\cos\zeta + \sin\zeta\right] + (R'/R'^2)\left[kR + kR'\cos\zeta - \sin\zeta\right]\right\},$$
$$\langle E\rangle_t = (A^2/4R^2R'^2)\left\{R^2/R'^2 + R'^2/R^2 + 2k^2(R^2 + R'^2) + 2k^2RR'\cos\zeta + 2(R\,R'/RR')\left[(1 + k^2RR')\cos\zeta + \zeta\sin\zeta\right]\right\}, \qquad (11.21)$$

where

$$\zeta = k(R' - R). \qquad (11.22)$$

The slope of the time average particle trajectories is then

$$\bar{w}_y/\bar{w}_x = \langle S_y\rangle_t / \langle S_x\rangle_t , \qquad (11.23)$$

where $\langle S_x\rangle_t$ and $\langle S_y\rangle_t$ may be obtained from the first of



Eqs.(11.21). Displaying these slopes on a rectangular grid the tajectories fitting these slopes that originate isotropically from each pinhole may be drawn. The trajectories for $D = 1.8\lambda = 3.6\pi/k$ are presented in Fig. 11.2.

To indicate the mechanical nature of the flux of slow particles of mass m that yields double pinhole interference the time-average potential $\bar{U}$ may be defined as

$$\bar{U} = E - m\bar{w}^2/2, \qquad (11.24)$$

where $E$ is the total energy of a particle. This potential U from Eqs.(11.24), (11.20), and (11.21) is shown in Fig. 11.3 for $D = 1.8\lambda = 3.6\pi/k$. A double slit interference pattern for slow electrons has been experimentally observed by Möllenstedt and Jönson (1959).

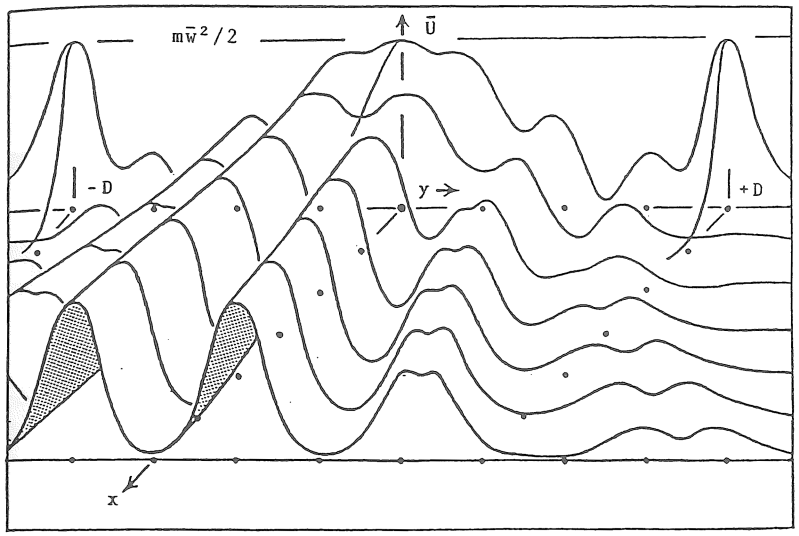



Fig. 11.3 The time-average potential U for double pinhole interference for slow particles of nonzero rest mass, Eqs.(11.24), (11.20) and (11.21), where the distance between pinholes is $2D = 3.6\lambda$. Measure marks are D/4 apart.

The flow pattern for photons yielding double pinhole interference,

as shown in Fig. 11.2, has been experimentally observed by the author (unpublished), using two microwave sending antennas and a single detector (which were available as equipment used to demonstrate Young's double pinhole interference to undergraduate physics students).

11.4c Other examples of particle or photon flow yielding wave behavior - Many explicit examples of how particle flow yields wave behavior have been presented in the literature. The particle trajectories yielding the knife edge diffraction pattern has been given by Wesley (1983j).

It is the initial particle position in a beam incident on a plane surface to a refracting medium that determines which particles are reflected and which are refracted (Wesley 1983k, 1987). No nonobserved "wave amplitude" nor probabilities are involved. In general, the initial quantum particle positions and velocities determine uniquely the subsequent motion yielding wave effects, precisely as demanded by classical Newtonian mechanics.

The trajectories giving rise to neutron interference in a single crystal Mach-Zehner interferometer have been derived by Wesley (1996k).

11.4d Causality and interference - Since the mathematical superposition of component waves cannot yield a scientific *causal* explanation for Young's double pinhole interference; a proper scientific *causal* explanation for the observed interference must be sought. Since light must deliver energy to produce an irreversible effect that permits it to be detected; the cause for interference must be traced along the path of the energy flux, the first of Eq.(11.9). Particles flowing along these paths *cause* the bright fringes. From Fig. 11.2 it is clear that the energy or particles producing an irreversible effect on the screen at a particular point pass through only *one* of the two pinholes and not through both (as claimed by the orthodox quantum mechanics). The energy carried by quantum particles, that can yield irreversible effects, is an *active cause*; while the forces normal to the trajectories, that guide the quantum particles along the trajectories are *passive causes*; as they involve no energy transfer.



Before particles can interfere and exhibit wave behavior they must be first prepared in a mutual state of *coherence*, where they become ordered in a rigid crystalline type array, spaced according to their relative phases. Such a state of coherence may be achieved by bringing as many particles as possible together in as small a volume as possible and holding them together as long as possible.

When such a rigid orderly array is released and allowed to move as a unit through space, it gives the impression of a propagating wave for a stationary observer. Similarly, a sinusoidally bent wire coat hanger, when moved through space will also generate a propagating wave for a stationary observer with a phase velocity $v$ equal to the velocity of the coat hanger, a wavelength $\lambda$ equal to the distance between two identical points on the coat hanger, and a frequency equal to $f = v/\lambda$ .

When such a rigid coherent array of quantum particles is divided into two portions, such as when the two portions pass through two different pinholes, and are then brought together, the two portions interact with forces that depend upon the relative phases of the two portions. The two portions are then diverted (such as shown in Fig. 11.2) to produce an interference pattern.

The forces producing the interaction between the two coherent arrays need not be long range. A *short range* phase dependent force between near neighboring particles is sufficient to bring an entire array into a state of mutual motion. Such short range mutual interactions between individual neighboring particles, that yield common mutual macrosopic motion, are well known in hydrodynamics and in solid state physics. *Short range* forces in a medium of many particles, yielding long range effects, can give the impression that *long range forces* are involved. Pushing on one end of a log produces a force on the far end causing it to move.

As in a fluid, or in a solid, an individual mass element, or "particle" may be considered in order to examine the forces and inertial properties within the medium that give rise to observed macroscopic behavior. The internal mutual forces between the mass elements or "particles" that yield no macroscopic effect are thereby ignored. Precisely the same situation exists for interference phenomena: The mutual interactions between the quantum particles

that give rise to a coherent array, need not be known in order to predict the macroscopic behavior of the entire array. Thus, the mean quantum potential $\bar{U}$, shown in Fig. 11.3, refers to the potential (and thus the force) that gives rise to the macroscopic motion of the array. The *single particle* of mass m is merely representative of the array at a particular point at a particular time. The forces between the individual particles in the array that do not affect the common motion are not considered. These forces merely serve to bond the entire array together as a cohesive liquid or solid substance. They play no role in terms of the macroscopic behavior.

However, these internal short range forces between neighboring particles, that bond the entire array together as a liquid or solid, accounts for the apparent *long range forces* that seem to act between widely separated quantum particles (such as between the quantum particles just emanating out of two widely separated pinholes).

Of course, these *long range forces* yielding wave behavior will vanish when the distances involved are greater than the "coherence length", that is, when the two widely separated particles are no longer coherently phase related to each other. Thus, for example, ordinary light sources, with a coherency length of about 1 m, will exhibit such long range coherency forces only over distances up to a meter. Laser light, with coherency lengths of about 100 meters, will exhibit such long range coherency forces up to about 100 m. The coherence lengths of particles with a finite rest mass, such as electrons and neutrons are much smaller.

This picture to explain the physical causes for the production of interference patterns by quantum particles is not simple (as compared with the simple-minded superposition of component waves erroneously interpreted as representing physical causality); but it appears to be sound scientific physics.

11.4e True waves or a flux of quantum particles? - *Wave behavior* alone is not sufficient to indicate whether the underlying phenomenon is a *true wave* (such a sound wave) or is a *flux of particles*. An elastic wave does not involve a net flow of particles ("phonons" are, in this case, merely mathematical fictions). An elastic wave, thus, represents a *true wave*. Light, on-the-other-hand, is observed



to travel through empty space involving no medium. (The luminiferous ether is a fictitious medium.) Thus, light must be a flux of particles, or photons, exhibiting wave behavior. Similarly a flux of electrons, that are known to be particles, each with a particular mass and charge, can also exhibit wave properties. Electrons can also travel through empty space without a medium being necessary to elicit their wave behavior.

Additional evidence, besides wave behavior, is, thus, required to know whether the phenomenon propagated is a *true wave* or else a *flux of particles*.

## 11.5 Reflection and Refraction at an Interface

Scientific quantum theory must show how a flux of photons behave when incident upon a plane surface separating empty space from a refracting medium. It is not sufficient to merely predict "intensities", as in the pure classical erroneous wave theory that ignores the energy flux. The orthodox Copenhagen view that it is only possible to predict a *probability* that an incident photon will be either reflected or refracted, or even where it might be, is also not scientifically admissible. Scientific quantum theory must show that the motion of any quantum particle is predicted with certainty in terms of its initial conditions, precisely as required in classical mechanics. *Science* must always allow for definite precise prediction (which is precluded by the orthodox *probabilistic* prediction). (A complete discussion of reflection and refraction may be found in Wesley's (1983j) *Causal Quantum Theory* book.)

11.5a The refraction of light agrees with Newton's photon theory - According to Newton a photon must possess momentum. If a photon behaves the same as a classical mechanical particle, then its momentum in a medium should be greater than in free space; because photon trajectories are observed to be bent toward the normal upon entering a refracting medium. In particular, a force acting on a photon when passing across a boundary into a medium must, from symmetry, act normal to the surface. Thus, a change in momentum can only be in its normal component; and no change in the tangential component can arise; thus,

$$p_1 \sin\Theta_1 = p_2 \sin\Theta_2, \tag{11.25}$$

where $p_1$ is the momenum in empty space with an angle of incidence $\Theta_1$ and where $p_2$ is the momentum in the medium with the angle of refraction $\Theta_2$. From Snell's law the ratio of the momenta is then given by

$$p_2/p_1 = \sin\Theta_1/\sin\Theta_2 = n, \tag{11.26}$$

where n is the index of refraction. Since $\Theta_2 < \Theta_1$ and $n > 1$; $p_2 > p_1$.

If the momentum of a photon were proportional to its velocity, as is true for a particle with a nonzero rest mass, then the velocity of a photon would have to be greater in a medium than in free space. Fizeau (1848), 1851) and Foucault (1850, 1860) measured the velocity of light u in a medium and found it to be less than the velocity in empty space c such that

$$u = c/n, \tag{11.27}$$

This evidence was then used to claim that Newton's photon theory for light was wrong.

However, unlike particles with a nonzero rest mass, the *momentum* of a photon varies inversely as the velocity of the photon. According to electrodynamic theory the momentum flux of light is proportional to the energy flux of light divided by the velocity of light u, Consequently, the energy of an individual photon must be proportional to its momentum times its velocity; thus,

$$E = \mathbf{p}\cdot\mathbf{u} = p_1 c = p_2 u. \tag{11.28}$$

Considering the conservation of energy across the boundary, Eq.(11.28), the ratio $p_2/p_1$ becomes

$$p_2/p_1 = c/u = n > 1. \tag{11.29}$$

Newton's photon theory of light is, thus, confirmed: The momentum of a photon is greater in a medium as in free space; as evident when the *correct* expression for the momentum of a photon, $p_2 = E/u$, is used.

Since the velocity of light in a medium u is less than c; a photon in a medium may be assigned a nonzero rest mass $m_o$, such that



$$p_2 = m_o u\gamma = m_o u/\sqrt{1 - u^2/c^2} = m_o c/\sqrt{n^2 - 1}\ . \tag{11.30}$$

From Eqs.(11.28) and (11.30) the rest mass of a photon in a medium than becomes

$$m_o = p_2\sqrt{n^2 - 1}/c = (E/c^2)n\sqrt{n^2 - 1}\ . \tag{11.31}$$

From Eqs.(11.31) and (11.30) a photon entering a material medium from free space falls into a potential well U given by

$$U = E - m_o c^2\gamma = -E(n^2 - 1). \tag{11.32}$$

The "photon" in a material medium is actually a fictitious particle; because the propagated phenomenon is coupled to the atoms of the material medium. In particular, the slower net apparent velocity of a photon in a medium is due to the photon becoming periodically attached to atoms of the medium for a fixed time delay before being reradiated with the *absolute* free space velocity c. This "fixed time delay theory" (Wesley 1996n) for light propagating in a medium is found to be *necessary* in order to account *exactly* for the observed velocity of light in a *moving* medium.

The behavior of light in a medium can yield no clear evidence for or against the particle flux theory of light; as the transmission of light through a medium is a complex phenomenon.

11.5b Particle trajectories for reflection and refraction - Four regions of interest, as shown in Fig. 11.3, may be considered: I the region of the incident wave $\Psi_i = A\sin(\mathbf{k}_i\cdot\mathbf{r} - \omega t)$, II the region of the *mathematical* superposition of the incident and reflected waves $\Psi_i + \Psi_r = A\sin(\mathbf{k}_i\cdot\mathbf{r} - \omega t) + B\sin(\mathbf{k}_r\cdot\mathbf{r} - \omega t)$, III the region of the reflected wave $\Psi_r = B\sin(\mathbf{k}_r\cdot\mathbf{r} - \omega t)$, and IV the region of the transmitted wave $\Psi_t = C\sin(\mathbf{k}_t\cdot\mathbf{r} - \omega t)$. From the law of reflection and Snell's law

$$k_i \sin\Theta_1 = k_r \sin\Theta_1 = k_t \sin\Theta_2, \tag{11.33}$$

where $k_i = k_r = k_t/n$ and

$$\begin{aligned} \mathbf{k}_i/k_i &= \sin\Theta_1\,\mathbf{e}_x - \cos\Theta_1\,\mathbf{e}_y, \quad \mathbf{k}_r/k_r = \sin\Theta_1\,\mathbf{e}_x + \cos\Theta_1\,\mathbf{e}_y, \\ \mathbf{k}_t/k_t &= \sin\Theta_2\,\mathbf{e}_x - \cos\Theta_2\,\mathbf{e}_y = \sin\Theta_1\,\mathbf{e}_x - \sqrt{n^2 - \sin^2\Theta_1}\,\mathbf{e}_y\ . \end{aligned} \tag{11.34}$$

The boundary conditions from electrodynamic theory (Wesley 1983j) require the wave functions be equal on the boundary between regions

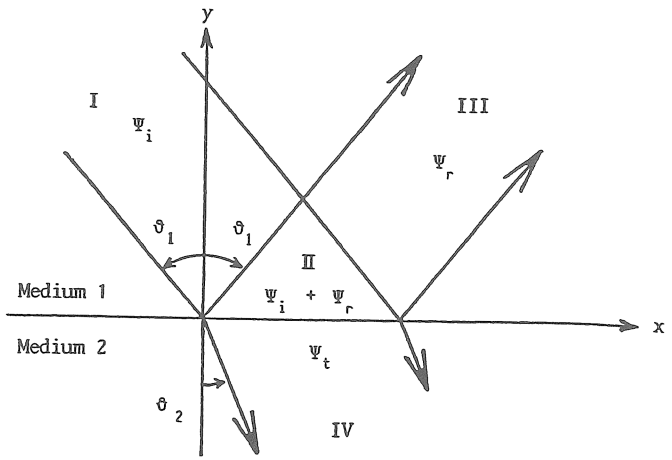



Fig. 11.3 Geometry for the reflection and refraction of a plane wave at a dielectric interface.

II and IV, which then yields the ratios

$$N_1 = B/A \qquad \text{and} \qquad N_2 = C/A, \tag{11.35}$$

where $N_1^2 = R$ is the reflection coefficient and $N_2^2 = T$ is the transmission coefficient. Substituting the wave functions that are appropriate for the different regions into the expression for the energy flux, the first of Eqs.(11.9), the time average energy flux in the interference region II is given by

$$\begin{aligned} \langle S_x \rangle &= (\omega k_i/2)(1 + N_1^2 + 2N_1 \cos 2\eta) \sin\Theta_1 , \\ \langle S_y \rangle &= -(\omega k_i/2)(1 - N_1^2) \cos\Theta_1 , \end{aligned} \tag{11.36}$$

where $\eta = k_i \cos\Theta_1 y$.

Since the term $2N_1 \cos 2\eta$ in the first of Eqs.(11.36) changes sign for $\delta\eta = \pi$, or $\delta y \sim \lambda/2$, which can lead to lateral displacements of the photons of no more than $\delta r = c\,\delta t = c(\delta y/2c) \sim \lambda/4$; the small wiggle represented by this term may be neglected macroscopically. The trajectories in the interference region II may then be approximated by the straight lines



$$y = \left[\langle S_y \rangle / \langle S_x \rangle\right](x - b) = -\cot\Theta_1 \left[(1 - N_1^2)/(1 + N_1^2)\right](x - b), \tag{11.37}$$

as indicated in Fig. 11.4, where b is a constant of integration equal to the intercept when y = 0.

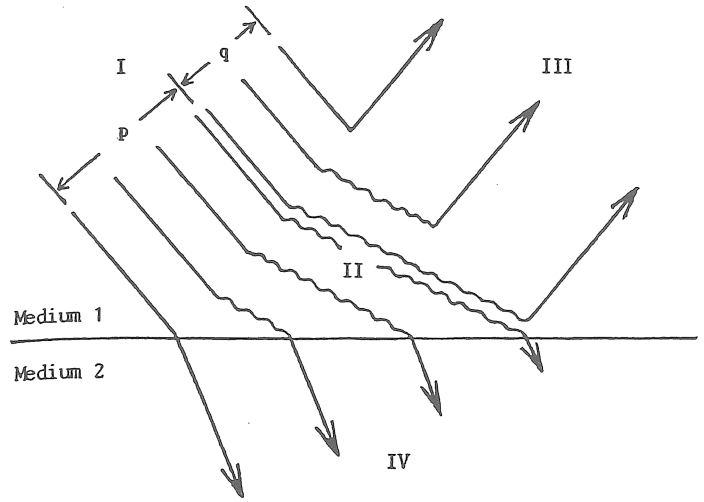



Fig. 11.4 Photon trajectories for reflection and refraction of a plane wave at an interface.

It may be seen from Fig. 11.4 that every photon that reaches the interface is transmitted into the medium; while every photon that is reflected is diverted from the interface before reaching it. All photons in the portion of the incident beam p are transmitted; while all photons in the incident portion q are reflected. It is clear that the initial conditions for a photon determine its subsequent motion, precisely as in classical mechanics. No intrinsic probabilities nor "intensities" are required. It may be readily proved (Wesley 1983j) that the reflection coefficient is given by

$$R = N_1^2 = q/(p + q), \tag{11.38}$$

as it should.

For an ideal mirror, where R = 1 and p = 0, the trajectories in

the interference region II become straight lines parallel to the surface, no photon reaching the surface.

For the case of total internal reflection the photons follow trajectories that pass from the medium into empty space and then curve back into the medium (Wesley 1983j).

For the case of penetration of a barrier, such as an air gap between two plates of glass (as investigated by Newton) some photons pass into the second plate of glass from the first without violating the conservation of energy nor without any intrinsic probabilistic behavior having to be assumed (Wesley 1983j).

## 11.6 Single Particles Do Not Exhibit Wave Behavior

The orthodox Copenhagen quantum mechanics presents the impossible mystical view that a very small "point" particle is actually smeared out over all space. Thus, the wave function $\Psi$, which is defined throughout all space, is supposed to represent a single small "point" particle. A single particle is supposed to be able to go through two widely separated slits simultaneously and is then supposed to be able to "interfere with itself". To try to get around these absurdities the orthodox theory claims that no actual particle trajectories exist. Only a "probability density" $\Psi\Psi^*$ of finding the particle at a particular position is supposed to be possible. Interference is not supposed to actually involve the particle itself; only "probability amplitudes" $\Psi_1$ and $\Psi_2$ are supposed to interfere by superposition to cause a resultant probability density $(\Psi_1 + \Psi_2)(\Psi_1^* + \Psi_2^*)$. Etc.!

As discussed above in Sections 11.2 through 11.5 scientific quantum theory avoids all of these impossible absurdities of the orthodox quantum theory by postulating that a flux of many quantum particles coherently coupled is necessary to yield wave behavior. Scientific quantum theory, thus, provides a hydrodynamic representation of wave phenomena that is mathematically isomorphic to the usual wave formalism.

The wave function $\Psi$ in this case of particle flow is simply a mathematical generating function for the hydrodynamic flow of many particles that yields wave behavior. The $\Psi$ function can be used to



generate the particle trajectories that produce interference patterns. The force field guiding the particles along these trajectories is also generated by the $\Psi$ function. In particular, *All* phenomena attributed to "waves" may be duplicated by quantum particles, whose motion is prescribed by the $\Psi$ function. It is the special coherent coupling among a flux of quantum particles that is responsible for the wave behavior.

As discussed below in Section 11.8 and 11.9, a *single* quantum particle's motion, including the constants of the motion, in a classical force field is also determined by a wave function $\Psi$, satisfying a wave equation, that is again merely a mathematical generating function. The requirement that the quantum particle motion be compatible with a wave function $\Psi$ guarantees that the *single* quantum particle's motion is governed by precisely the same coherent coupling forces giving rise to actual wave behavior when a large number of such particles are coupled together as a flux. The single particle cannot, of course, exhibit any wave behavior when it is not coupled to any coherent near neighbors or to a classical force field. Scientific quantum theory rejects the impossible idea that the single electron in a hydrogen atom is itself a wave, existing throughout all space.

## 11.7 Scientific Quantum Theory Involving $\hbar$

Although quantum theory, as a study of natural phenomena involving integral units and integers, is many centuries old; the word "quantum" today is primarily associated with phenomena that involve Planck's constant $\hbar$.

11.7a Planck's discovery of the constant $\hbar$ – Planck (1900, 1901) first introduced the constant to fit the observed black body radiation flux as a function of frequency. Shortly thereafter he was able to derive this black body radiation formula by assuming the electromagnetic radiation from the atomic oscillators in the walls of the cavity radiated *energy* only in integral units of the angular frequency $\omega$ such that

$$E = \hbar\omega . \tag{11.39}$$

The theory for black body radiation and Planck's derivation of his black body radiation formula is rather involved (Wesley 19831); so it will not be discussed here. There are so many simpler situations that have subsequently been discovered that involve $\hbar$; so here it will be sufficient to discuss the simplest example, that of the "free particle wave".

11.7b The Wesley (1965) wave – Since the individual particles in a flux of particles, exhibiting wave behavior, transport the energy and momentum of the wave; the phase velocity of the wave in empty space, that equals the velocity of energy and momentum propagation, *must* then also equal the particle velocity. It is consequently *empirically required* that the "free particle wave" *must* be given by

$$\Psi = A \sin\left[\mathbf{k}\cdot(\mathbf{r} - \mathbf{v}t)\right], \tag{11.40}$$

where k is the an appropriate propagation constant and v, the phase velocity of the wave is also the free particle velocity. The mathematical wave accompanies the physical particles. The wave aspect of the particle flux is necessarily tied to the particles themselves (in contrast to the erroneous orthodox Copenhagen quantum mechanics, where the wave velocity is independent of the particle velocity).

Assuming that light is a flux of photons obeying the Planck radiation condition (11.39), then the angular frequency is given by

$$\omega = \mathbf{k}\cdot\mathbf{v} = E/\hbar. \tag{11.41}$$

This required result (11.41) is seen to satisfy the relationship between energy and the wave velocity v for light, Eq.(11.28), if the momentum of the photon is given by

$$\mathbf{p} = \hbar\mathbf{k}; \qquad \text{so} \qquad \lambda = 2\pi\hbar/|\mathbf{p}|, \tag{11.42}$$

where $\lambda$ is the so-called "de Broglie wavelength". This wavelength, Eq.(11.42), agrees with the observed wavelength of light, as well as the observed wavelength of electrons and other quantum particles with a nonzero rest mass.

Thus, for any particle flux exhibiting wave behavior and satisfying the Planck quantum condition (11.41) the empirically



*necessary* "free particle wave" becomes

$$\Psi = A \sin\left[\mathbf{p}\cdot(\mathbf{r} - \mathbf{v}t)/\hbar\right], \tag{11.43}$$

the "Wesley wave".

(This empirically necessary and rather obvious derivation of the wavelength to be associated with a flux of quantum particles given by Eq.(11.42) may be compared with de Broglie's (1923,1924) physically untenable derivation of his empirically impossible "de Broglie wave", given by

$$\Psi = A \exp\left[i(\mathbf{p}\cdot\mathbf{r} - Et)/\hbar\right], \tag{11.44}$$

where E is supposed to be the total energy, including the rest mass energy of the particle with a nonzero rest mass; or else it is supposed to be the total classical kinetic energy of the particle. The wavelength of this impossible "de Broglie wave" happens to also be $\lambda = 2\pi\hbar/|\mathbf{p}|$, as given by Eq.(11.42), the observed wavelength for quantum particles.

de Broglie assumed: 1) A particle of mass m has a Compton frequency $\omega_c = c^2 m/\hbar$, that has, unfortunately, never been observed. 2) The phase of his matter wave was taken to be a "Lorentz invariant" as required by the "special relativity" nonsense. The phase is the scalar product of the 4-vector momentum (p, E/c) and the 4-vector position (r, ct). 3) From the Planck frequency condition (11.39) and a physically inadmissible "Lorentz transformation" from the frame fixed to the moving particle the quantity $(-c^2 mt/\hbar)$ was transformed to $(\mathbf{p}\cdot\mathbf{r} - Et)$ for the stationary observer, the phase of the de Brogle wave. 4) Unfortunately, de Broglie overlooked the embarrassing elementary fact that an oscillating system when translated yields a *standing wave* and not a *propagating wave*. Only a time independent periodic structure, such as a sinusoidally bent wire coat hanger can yield a propagating wave when translated. 5) Unfortunately, de Broglie represented his "wave" in complex exponential notation involving the imaginary number $i = \sqrt{-1}$; so that whether a sine or a cosine function is to be used is a matter of indifference and actual wave phenomena, such as interference, cannot be predicted. 6) Unfortunately, the de Broglie frequency $\omega = c^2 m\gamma/\hbar$, where $\gamma = 1/\sqrt{1 - v^2/c^2}$ has never been observed for a quantum particle of

nonzero rest mass. 7) Unfortunately, the de Broglie phase velocity $u = (E/\hbar)/(|p|/\hbar) = c^2 m\gamma/m\gamma|v| = c^2/|v|$ goes to infinity when the particle comes to rest. And the free space wave velocity that is supposed to be the velocity of the energy propagation is not the same as the particle velocity that is also supposed to carry the energy. 8) Unfortunately, when the energy E is taken to be the classical kinetic energy for a free particle, the phase velocity, being $u = (mv^2/2)/mv = v/2$, then means that the wave itself can never catch up with the particle. 9) Unfortunately, the attempt to rescue the impossible de Broglie wave by postulating, ad hoc, that it is a "group wave" with a group velocity given by the irrelevant mathematical *identity* $u = 1/(dk/d\omega) = dE/dp = (d/dp)\left(c\sqrt{c^2m^2 + p^2}\right) = v$, fails; because: a) A group wave cannot exist in empty space. b) For a group wave to exist the necessary spread in frequencies would mean that the particle could have no unique energy. And c) there is no physical evidence that a group wave exists!

## 11.8 Wave Equations for Quantum Particle Motion

Empirically a flux of quantum particles is observed to yield a free space wave given by the Wesley wave Eq.(11.43), where the phase velocity is the individual particle velocity v. The wave function $\Psi$, Eq.(11.43), for this wave is a solution to the wave equation

$$\nabla^2\Psi - \partial^2\Psi/\partial t^2 v^2 = 0, \tag{11.45}$$

subject to no boundaries nor boundary conditions.

Solutions to the wave equation (11.45) may be generalized to include solutions subject to appropriate boundary conditions. For example, for a rigid screen with two pinholes and the boundary condition that $\partial\Psi/\partial n = 0$ on the screen (except at the pinholes) yields the Young's double pinhole interference pattern, where $\Psi$ is given by the sum of Eqs.(11.18).

The wave or phase velocity v to be used in the wave equation (11.45) plus boundary conditions is to be chosen as the free space particle velocity, as though no boundaries were present. The actual particle velocity does not, however, remain the same; it is given



instead by Eqs.(11.9) and (11.14); thus,

$$w = S/E, \tag{11.46}$$

which is no longer necessarily v. Thus, the *phase* velocity is to be chosen as the classical particle velocity, involving *no wave effects* when no boundaries or boundary conditions are present. The true particle velocity, including wave effects, is then given by Eq.(11.46) using solutions to the wave equation (11.45) satisfying the appropriate boundary conditions.

This is a phenomenological approach to fit the empirical observations. It is a recipe to generate the right answers. It does not, unfortunately, provide the underlying physical cause for *why* this recipe works. An actual physical explanation would probably yield Planck's constant $\hbar$ in terms of more fundamental physical constants. No such explanation is available today.

If the wave effects are small compared with the classical particle flux, that involves no wave effects, then it is possible to view classical mechanics as providing the first approximation as v; while the true particle velocity w, as given by Eq.(11.46), may then be regarded as the second order or final approximation.

## 11.9 Bound Particle Motion for Time Harmonic Standing Waves

The wave equation (11.45) also admits standing wave solutions. Particle fluxes that produce this standing wave behavior may also be prescribed by Eqs.(11.14), (11.15), (11.9) and (11.45). Standing waves occur in bounded systems; so the particles giving rise to standing waves are bound particles.

The wave Eq.(11.45) may be separated into a space part $\psi(\mathbf{r})$ and a time part T(t) if $\Psi(\mathbf{r},t)$ can be expressed as the product

$$\Psi(\mathbf{r},t) = \psi(\mathbf{r})T(t), \tag{11.47}$$

which yields

$$v^2\nabla^2\psi/\psi - (\partial^2 T/\partial t^2)/T = 0. \tag{11.48}$$

For a sinusoidal variation with time with a *fixed* angular frequency $\omega$, where

$$T(t) = \sin(\omega t), \tag{11.49}$$

Eq.(11.48) reduces to the Helmholtz equation for the space part,

$$\nabla^2\psi + k^2\psi = 0. \tag{11.50}$$

From the Wesley wave, Eq.(11.43), the propagation constant is $k = p/\hbar$; so

$$k^2 = p^2/\hbar^2; \tag{11.51}$$

and Eq.(11.50) becomes

$$\nabla^2\psi + (p/\hbar)^2\psi = 0. \tag{11.52}$$

For photons $p = E/c$. For fast particles of nonzero rest mass, according to neomechanics, $p = mv\gamma = \sqrt{E^2 - m^2c^4}/c$. And for slow particles $p = mv = \sqrt{2mE}$, where E is the classical kinetic energy.

## 11.10 A "Particle in a Box"

The simplest case of bound quantum particle motion giving rise to standing waves with harmonic time variation and constant phase velocity is presented by a linear plane standing wave confined between two boundaries at x = 0 and L on which the $\psi$ is zero. The quantized wave solutions to the Helmholtz Eq.(11.50) satisfying the boundary conditions is then

$$\psi_n = A_n \sin(n\pi x/L), \tag{11.53}$$

where the "classical" momenta from Eq.(11,51) are restricted to the quantized values

$$p_n = n\pi\hbar/L = \hbar k. \tag{11.54}$$

From Eq.(11.28) the energy for photons or light is also quantized as

$$E_n = p_n c = n\pi\hbar c/L = \hbar\omega. \tag{11.55}$$

For slow particles with a finite rest mass the quantized energies are given by

$$E_n = n^2\pi^2\hbar^2/2mL^2 = \hbar\omega/2, \tag{11.56}$$

where $E_n$ is the total energy equal to the "classical kinetic energy". For fast particles with a nonzero rest mass the quantized energy becomes

$$E_n = c^2 m\sqrt{1 + n^2\pi^2\hbar^2/c^2m^2} = \hbar\omega, \tag{11.57}$$

where $E_n$ is the total energy including the rest mass energy.



The motion for a particle in a box is given by substituting Eqs.(11.53), (11.49), and (11.47) into Eq.(11.9), yielding

$$S_x = -k\omega A^2 \cos kx \sin kx \sin\omega t \cos\omega t,$$
$$E = k^2A^2(\cos^2 kx \sin^2\omega t + \sin^2 kx \cos^2\omega t)/2, \tag{11.58}$$

where k is given by Eq.(11.4) and $\omega$ by (11.54), (11.56), or (11.57). The motion is then given by integrating

$$dx/dt = S_x/E = -u \sin 2kx \sin 2\omega t/(1 - \cos 2kx \cos 2\omega t), \tag{11.59}$$

where $u = \omega/k$ is the phase velocity. Integrating Eq.(11.59) yields

$$2k(x - x_o) = \sin 2kx \cos 2\omega t, \tag{11.60}$$

where $x_o$ is a constant of integration, which is a mean position when $2\omega t = (2n' + 1)/2$, where n' is an integer.

Since $|\cos 2\omega t| \leq 1$; the values of x lie in the range given by

$$|2k(x - x_o)/\sin 2kx| \leq 1; \tag{11.61}$$

and the turning points of the motion $x_1$ and $x_2$, where $x_1 < x_o < x_2$, are given by

$$\sin 2kx_1 = 2k(x_o - x_1) \quad \text{and} \quad \sin 2kx_2 = 2k(x_2 - x_o). \tag{11.62}$$

The motion is shown in Fig. 11.5 for the position as $kx/\pi = nx/L$ (the ordinate) as a function of the time as $\omega t$ (the abscissa) for a uniform distribution of the initial position $x_o$.

Classically a particle in a box is supposed to be able to travel the whole length of the one dimensional box to be reflected from the walls at x = 0 and L perfectly elastically. Wave behavior precludes this freedom. A quantum particle is confined to only one of the 2n possible half cells of width $\lambda/4 = L/2n$; since the particle cannot cross a nodal surface, where $\sin(n\pi x/L) = 0$. In order for the wave behavior to arise it must be assumed that many quantum particles are in the box. The mutual coherent interaction among these particles acting on each other at a distance then gives rise to the standing wave behavior.

It might seem strange that the quantum particles are confined to half cells, instead of an entire cell; but the energy flux and density of a violin string behaves in precisely the same manner. The energy flows outward from a loop toward a node, where it then

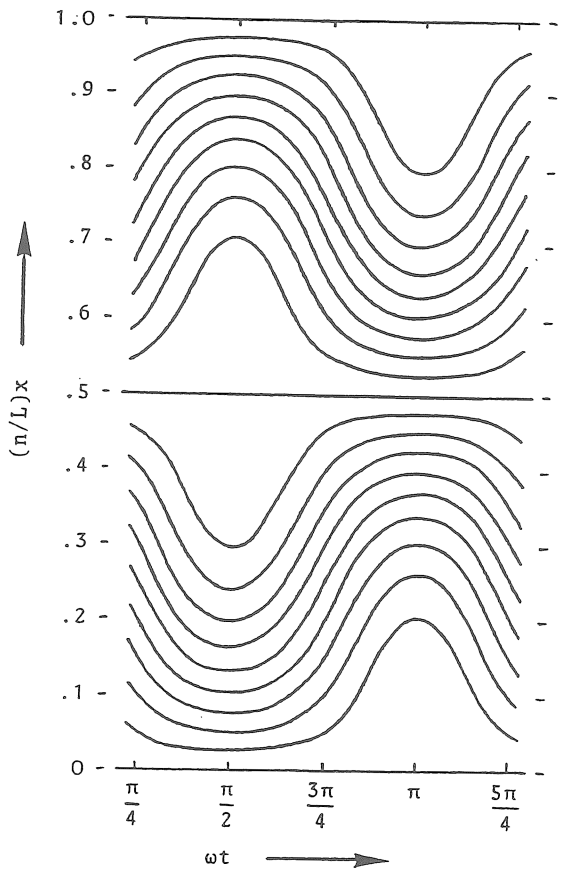



Fig. 11.5 Particle position as a function of the time for a particle in a box for a uniform distribution of the constant of integration $x_o$ for one of the n possible cells.

reverses direction to flow back toward the loop all within half a period.

(This scientific result for the particle (or particles) in a box problem is in drastic contrast to the orthodox Schroedinger or Copenhagen quantum mechanics, that claims bound quantum particles are *motionless*. But at the same time they are supposed to have energy,



auch as prescribed by Eq.(11.55), (11.56), or (11.57) for a particle in a box, which is nonzero and which can only be kinetic energy, implying *motion*. The (presumably time average) likelihood of finding the particle in a box per unit length, according to the orthodox theory, is supposed to be $\psi\psi^* = (2n\pi/L)\sin^2(n\pi x/L)$, instead of simply 1/L as given by the second of Eqs.(11.58) averaged over a cycle and normalized to unity. According to orthodoxy the particle is not even supposed to exist unless it is observed. According to the orthodox theory, the particle is supposed to be smeared out over all of the n possible cells of width L/n each, instead of being held in only *one* of the small cells, rigidly separated from all of the other cells, as indicated in Fig. 11.5. An act of observation is supposed to cause the particle to appear at some discrete position. Etc.!)

## 11.11 Planck-Debye Quantum Statistics

Particles that have an intrinsic integer spin angular momentum $n\hbar$, where n is an integer, such as photons with n = 1, are found to obey the quantum statistics first developed by Planck (1900, 1902) and subsequently by Debye for solids. (Traditionally this statistics is inappropriately called "Bose-Einstein statistics". They introduced intrinsic probabilities in an attempt to show that the Planck-Debye statistics was merely classical Boltzmann statistics. Their scientifically inadmissible intrinsic probabilities was subsequently used to try to excuse the inadmissible intrinsic probabilities in orthodox quantum mechanics.)

It is of interest to know how energy of a statistical thermodynamic system is divided among the various possible energy modes. The statistical weight or "probability" of a particular macrostate of a system is taken as proportional to the number of microstates that can yield the same macrostate.

11.11a Lord Rayleigh's weighting factor - The number of ways, or modes, that energy can be stored in a one dimensional box containing standing waves, as given by Eq.(11.53), is n, the number of cells possible. For a three dimensional box standing waves can exist in all three dimensions; so the number of modes in number space is

given by

$$N_n = 4\pi n^3/3. \tag{11.63}$$

The integer n is related to the frequency $\nu$ according to

$$\nu = uk_n/2\pi = un/2L, \tag{11.64}$$

where u is the phase velocity from Eq.(11.54). Generalized to three dimensions for the volume V

$$\nu = un/V^{1/3}. \tag{11.65}$$

Substituting this result (11.65) into (11.63) then yields the number of modes per frequency interval per unit volume as

$$d^2N/d\nu dV = 4\pi\nu^2/u^3, \tag{11.66}$$

which is Lord Rayleigh's weighting factor.

For light two polarization modes are possible; so for light Eq.(11.66) is to be multiplied by 2. In terms of the energy, where $\nu = \varepsilon/h$, where $h = 2\pi\hbar$, the original Planck constant, and $\varepsilon$ is the energy of an individual photon, then yields

$$d^2N/d\varepsilon dV = 8\pi\varepsilon^2/h^2c^3. \tag{11.67}$$

11.11b Statistical weight for each microstate characterized by n - Each possible microstate, involving n cells, cannot be weighted equally; since some cells may be occupied by many photons and some cells by none. Thus, if there are $P_n$ photons of the same energy $h\nu$ to be distributed among n cells, the number of possible microstates characterizing the macrostate is given by the permutation of $P_n$ things in n bins, involving n - 1 partitions, equal to $(P_n + n - 1)!$. Since the permutations of the n - 1 partitions gives rise to no new physical microstates; the appropriate statistical weight W' becomes

$$W' = (P_n + n - 1)!/(n - 1)!. \tag{11.68}$$

This weight W' assumes a different physical microstate for the exchange of photons or particles, each particle being *identifiable*. But physically a bound particle cannot cross a wave node; so there is no way that particles, or photons, can *physically* exchange their roles. The quantum system being treated consists of a rigid array of quantum particles held fixed in space inside of little boxes of



half-wavelength size $\lambda/2$. The system being treated is, thus, a *solid*. Since the particles cannot exchange their roles physically; the weight W', Eq.(11.68), must be divided by all of the possible permutations of the $P_n$ particles among themselves. Thus, the statistical weight to associate with n, or with a particular particle or photon energy $\varepsilon$ is then

$$W = (P_n + n - 1)!/(n - 1)!P_n!. \tag{11.69}$$

11.11c The orthodox particle "indistinguishability" does not exist - Copenhagen quantum mechanics introduces the "spooky", or mystical, idea that quantum particles are somehow "indistinguishable" so the exchange of two like quantum particles cannot give rise to a new microstate. Classical Boltzmann statistics counts the exchange of two like particles as a new microstate.

According to the traditional quantum mechanics, quantum particles are not supposed to be fixed in rigid coherent arrays, as revealed to be true by the scientific quantum theory. The orthodox idea of "indistinguishability" makes no sense; because a particle at a point *a* cannot be the same as a particle at a different point *b*, no matter how identical the two particles might be! In addition, rigid coherent arrays of different atomic isotopes should be possible, yielding precisely the same statistics; so the statistical weight W, as given by Eq.(11.69), should still remain valid for nonidentical particles that are easily *distinguishable*.

Two Nobel Prizes have been recently awarded for obtaining "Bose-Einstein condensates" that are supposed to represent a "new state of matter" involving a rigid array of atoms or molecules of even spin in a rigid array. This recognition by the orthodox physics community of the state of coherency should have been recognized 100 years ago with the confirmation of the existence of photons. Wesley (1983m) pointed out this coherency property explicitly about 20 years ago!

This rigid array state of coherence is not permanent. It is ordinarily quite transient. For example, light from ordinary sources has a coherence length of about one meter, or a coherence time of about $10^{-9}$ s. With special care lasers can be devised to produce light with coherence times of about $10^{-7}$ s, or coherence lengths of

about 100 m. The phenomenon of coherence is the phenomenon giving rise to the wave behavior of quantum particles. Perhaps the current efforts to make better "Bose-Einstein condensates" might eventually reveal the secret of the inter-particle forces that give rise to wave and quantum behavior.

It needs to be mentioned that light (and apparently other quantum particles) are emitted only as short high intensity coherent bursts with long periods in-between devoid of any light at all. This property is particularly noticeable for laser light. Since interference can only occur between photons in a coherent burst of short duration; interference generally occurs during the brief period of high intensity bursts. Due to the long periods when no light at all is radiated very low long-time-average light intensities still seem to yield interference. Thus, with the false assumption that photons are radiated continuously from a light source, it has been assumed that single photons, one at a time, can produce interference patterns, or that photons can interfere with themselves. It is extremely difficult to obtain low enough intensity sources that demonstrate that interference does not occur with single photons (Dontsov and Baz 1967; Panarella 1982, 1987) and that interference is a multiple particle phenomenon.

11.11d The Planck black body radiation formula. - The entropy $S_n$ for a system of photons in a cavity is defined as k, the Boltzmann constant, times the logarithm of the statistical weight W of the system. From Eq.(11.69) for the n the entropy is

$$S_n = k\,ln\,W = k\left[\Sigma\, ln\,(P_n + n - 1) - \Sigma\, ln\,(n-1) - \Sigma\, ln\,P_n\right]. \quad (11.70)$$

Using Stirling's formula for $P_n$ and n large and maximizing the entropy for a variation in $P_n$ subject to the conservation of energy, then yields the condition

$$\delta\left[(P_n + n)\,ln\,(P_n + n) - n\,ln\,n - P_n\,ln\,P_n - \beta\varepsilon P_n\right] = 0, \quad (11.71)$$

where $\beta$ is a Lagrangian multiplier. The value of $P_n$ then becomes

$$P_n = n/(e^{\beta\varepsilon} - 1). \quad (11.72)$$

From the thermodynamic relation

$$\partial S/\partial E = 1/T, \quad (11.73)$$



Eqs.(11.70), (11.71), and (11.73), where $E = P_n\varepsilon$, yields $\beta = 1/kT$ for the Lagrangian multiplier.

The mean energy $E_n$ per value of n then becomes

$$E_n = P_n\varepsilon/n = \varepsilon/(e^{\varepsilon/kt} - 1). \quad (11.74)$$

This result, Eq.(11.74), may then be multiplied by the Lord Rayleigh weighting factor, Eq.(11.67), for the number of modes for the value of n or $\nu$ to obtain the internal energy per unit volume per unit frequency interval. Multiplying the result by c/4 for the rate the energy escapes from a half sphere in one direction from the cavity, Planck's black body radiation formula becomes

$$I_\nu = (2\pi h\nu^3/c^2)/(e^{h\nu/kT} - 1). \quad (11.75)$$

## 11.12 Fermi-Dirac Quantum Statistics

Quantum particles of half an odd integer spin, fermions, obey Fermi-Dirac statistics. The conducting electrons with spin 1/2 form a fermion gas in a metal. The Lord Rayleigh weighting factor, Eq.(11.66) remains the same. Only two fermions of opposite spin can occur in any one of the n possible cells. The "exclusion principle", limiting the number of fermions to two in a cell, is apparently a consequence of a repulsion between fermions of parallel spins. It means that $\psi$ functions for a system of fermions must vanish at the position of a fermion (Wesley 1983n).

The statistical weight for $P_n < n$ fermions with spin upward distributed among n cells such that a cell is either occupied or is not occupied is given by

$$W_n = n!/P_n!(n - P_n)!, \quad (11.76)$$

where again an interchange of fermions is not physically possible; as they are held apart in a rigid crystalline type array. Again the mystical orthodox "indistinguishability" of fermions is not required.

Maximizing the $S_n = ln\,W_n$, using Stirling's formula subject to the conservation of energy yields

$$P_n = n/(e^{(\varepsilon - \varepsilon_o)/kT} + 1), \quad (11.77)$$

where $\varepsilon_o$ is a constant "Fermi energy". The same result may be obtained for the fermions with the spin down; so the total energy

is proportional to $2\varepsilon P_n$. Combining Eq.(11.77) with the appropriate Lord Rayleigh weighting factor, Eq.(11.66), then gives the internal energy U per unit electron energy $\varepsilon$ per unit volume as

$$d^2U/d\varepsilon\, dV = \left[4\pi(2m\varepsilon)^{3/2}/h^3\right]\Big/\left[e^{(\varepsilon-\varepsilon_o)/kT}+1\right], \qquad (11.78)$$

the desired energy distribution formula for Fermi-Dirac statistics.

## 11.13 The Time Independent Schroedinger Equation

To satisfy both the condition for the motion of a bound particle with a nonzero rest mass in a classical force field as well as the wave condition; as prescribed by the wave equation (11.45) the phase velocity v is to be chosen as the classical particle velocity. In particular, the phase velocity v need not be chosen as a constant in general; it may be chosen as the classical variable particle velocity.

The wave Eq.(11.45) may be separated into a space part and a time part by assuming the $\Psi$ function may be written as the product of a function of space alone $\psi(r)$ and a function of time only T(t), as given by Eq.(11.47). Considering the Wesley wave, Eq.(11.44), the separated differential equations may then be taken as

$$\begin{aligned} \nabla^2\psi + (p/\hbar)^2\psi &= 0, \\ d^2T/dt^2 + (p\cdot v/\hbar)^2 T &= 0, \end{aligned} \qquad (11.79)$$

where $(p/\hbar)^2$ in the first of Eqs.(11.79) involves the classical momentum squared expressed in terms of the position only and where $(p\cdot v/\hbar)^2$ in the second of Eqs.(11.79) involves twice the classical kinetic energy squared expressed in terms of the time only.

For a particle moving in a potential field V(r), assuming neomechanics, where

$$p^2 = \left[(E' - V(r))^2 - m^2c^4\right]/c^2, \qquad (11.80)$$

the first of Eqs.(11.79) then becomes

$$c^2\hbar^2\nabla^2\psi + \left[(E' - V(r))^2 - m^2c^4\right]\psi = 0, \qquad (11.81)$$

which is the time independent Schroedinger (1926) equation for neomechanics, where E' is the total energy including the rest mass energy.



For a slow quantum particle $E' = E + mc^2$, where E is the classical mechanical total energy. Neglecting $(E - V)/mc^2$ compared with unity, Eq.(11.81) reduces to

$$(\hbar^2/2m)\nabla^2\psi + \left[E - V(r)\right]\psi = 0, \qquad (11.82)$$

the famous time independent Schroedinger (1926) equation for classical particle mechanics. This Eq.(11.82) has been astoundingly successful in yielding quantized energy levels, quantized orbital angular momenta, spectral line intensities, etc.

The time function T(t), is given by the second of Eqs.(11.79), which may also be written as

$$d^2T/dt^2 + 4K^2(t)T = 0, \qquad (11.83)$$

where K(t) is the kinetic energy of the particle expressed as a function of the time only.

The quantum particle velocity including wave effects is then given from Eqs.(11.9) and (11.14) by

$$w = S/E = -\frac{2\nabla(ln\psi)d(lnT)/dt}{\left[\nabla(ln\psi)\right]^2 + \left[d(lnT)/dtv\right]^2}. \qquad (11.84)$$

Integrating w, Eq.(11.84), with respect to time yields the quantum particle motion along a discrete trajectory as an explicit function of the time and the initial conditions, specifying the position and velocity at the initial time t = 0.

Some specific examples can be found in the literature: The motion of a particle along discrete trajectories as a function of time have been found for the simple harmonic oscillator (Wesley 1983o), where the particle is acted on by the potential $V = Cx^2$. The quantized motion as an explicit function of the time has been found for the rigid rotator (Wesley 1983p). The explicit motion along discrete trajectories as functions of time have been obtained (Wesley 1983q) for the electron in the hydrogen atom for some of the lower energy levels.

## 11.14 Scientific Quantum Theory Needs to Be Extended

Scientific quantum theory has not been applied to many areas involving quantum phenomena. In some of these areas there are very

successful empirical formulas and rules that permit excellent prediction. The basic cause for why a flux of particles should become coherent and yield wave behavior remains still a mystery. The word "scientific", as used here, is, thus, only partially warranted; as there remains so many quantum phenomena that need to be still explained.

For example, the Schroedinger (1926) formula that is so highly successful in predicting the intensity of spectral lines, which is proportional to

$$\int \psi_a^* x \psi_b \qquad (11.85)$$

for an "electric dipole" transition from state *a* to state *b*, is not explained in terms of the motion of the source electron or electrons. Scientific quantum theory needs to explain precisely why this Schroedinger formula (11,85) works. Does it really involve only a single isolated hydrogen atom; or is a whole macroscopic ensemble of the order of $10^{20}$ atoms, coupled together synchronously, involved?

Scientific quantum theory has also not been applied to the many problems involving spin. There are many successful empirical formulas and rules to predict angular momentum states involving spin, energy levels involving spin, and corresponding spectral line intensities involving spin; but the underlying scientific physics still needs to be illucidated.

The "Lamb shift" for the super-fine structure of the spectral lines of hydrogen can probably be explained by introducing the correct boundary conditions for the $\Psi$ function, such that $\Psi$ vanishes when $r = 0$, which means that the electron and proton cannot occupy the same position at the same time. "Vacuum fluctuations" and other pseudo-scientific methods, that are used to generate *correct* empirical results, offer no scientific explanation nor insight into the actual physics involved.

What is the internal structure of a photon with energy $\hbar\omega$ and spin one, that can, with other photons, yield the appropriate electric and magnetic fields?



## 11.15 Some Absurdities of Orthodox Quantum Mechanics

Despite some successful and useful empirical formulas, the orthodox Copenhagen quantum mechanics also contains many absurdities. It is of value to list a few of these absurdities; so future research in scientific quantum theory can proceed less encumbered.

11.15a The orthodox time variation cannot be correct - The orthodox time variation is invariably assumed to be given by the factor

$$\exp(-iEt/\hbar), \qquad (11.86)$$

where E is always taken to be a constant, the total energy of a particle. Although a sinusoidal variation with time with the fixed frequency $\omega = E/\hbar$ is valid for light, or a flux of photons in free space; it is not valid for particles with a nonzero rest mass. The frequency $E/\hbar$, where E is the total energy including the rest mass energy or the classical total energy, has never been observed for particles with nonzero rest masses. The correct scientific frequency $\omega = \mathbf{p}\cdot\mathbf{v}/\hbar$ is not necessarily constant. With the appropriate variable frequency bound quantum particle motion, as given by Eqs.(11.79) and (11.84), can be found as explicit functions of the time.

The orthodox fixed frequency $E/\hbar$ makes it impossible to predict how any physical property of a system can change explicitly as a function of time. The orthodox Copenhagen quantum theory is, thus, in fact, a time independent theory.

The complex representation, Eq.(11.86), is ambiguous. It implies some linear combination of the sine and cosine; but without any prescription of what combination is to be chosen it is impossible to fit any laboratory observations.

11.15b An orthodox quantum particle is not supposed to have a phase - A free particle is supposed to be represented by the complex de Broglie wave,

$$\Psi = \exp\left[i(\mathbf{p}\cdot\mathbf{r} - Et)/\hbar\right]. \qquad (11.87)$$

Since physically only a specific linear combination of the two real functions, the sine and the cosine, can be measured; the phase represented by Eq.(11.87) is, thus, empirically completely ambiguous

or unspecified. To get around this dilemma the orthodox quantum mechanics claims that a quantum particle can have no phase. But a *wave* (such as the de Broglie wave, Eq.(11.87), is supposed to represent) must have a precise phase in order to predict interference and diffraction phenomena. The precise phases of component waves must be known. A quantum particle without a phase can exhibit no wave properties!

Schroedinger (1926) original research is based upon Hamilton's (1834) geometrical optics approximation, that precludes any wave behavior and, thus, any need to prescribe a phase.

The de Broglie-Schroedinger wave packet, that is supposed to represent a particle, involves a spread in frequencies, that also requires a spread in phases with no precise phase. Thus, wave packets can yield no observable interference phenomena.

11.15c Orthodox particle density and flux are insufficient - Schroedinger (1926) postulated ad hoc a quantum particle flux $\mathbb{G}$ and density P, that together with the Schroedinger Eq.(11.82), satisfy the equation of continuity; thus,

$$\mathbb{G} = -(i\hbar/2m)(\Psi^*\nabla\Psi - \Psi\nabla\Psi^*), \qquad P = \Psi\Psi^*, \tag{11.88}$$

where an appropriate normalization factor is included in the $\Psi$ functions so that P integrated over all space yields unity. This arbitrary flux and density, Eq.(11.88), may be compared with the time dependent flux and density prescribed by the scientific quantum theory, Eqs.(11.9).

Since the $\Psi$ function is taken as pure real for bound particle motion; the particle flux, according to the first of Eqs.(11.88), is zero, $\mathbb{G} = 0$; bound particles are supposed to remain motionless according to the orthodox Schroedinger quantum mechanics. However, the hydrogen atom, for example, is supposed to be able to exist in different orbital angular momentum states. The orthodox idea of motionless bound particles is *absurd*.

The orthodox claim of motionless bound particles is also unable to account for the successes of the Bohr-Sommerfeld model for the hydrogen atom, where the electron, moving in discrete elliptical orbits, yields nonzero angular momentum states.



Since the orthodox time variation is always taken as the factor given in Eq.(11.86); the Schroedinger quantum particle flux and density, Eq.(11.88), are time independent. This means that, at best, the arbitrary Schroedinger choices, Eqs.(11.88), can only be compared with the *time-average* flux and density of the scientific theory, Eqs.(11.9). No transient problem can be solved by the orthodox theory - in contrast to the scientific theory.

11.15d Heisenberg's antiscientific "uncertainty principle" is empirically violated - The Heisenberg (1927) "uncertainty principle" states that the simultaneous knowledge of the value of two canonically conjugate variables p and q cannot be known to within mutual uncertainties $\Delta p$ and $\Delta q$ such that

$$\Delta p \Delta q > h. \tag{11.89}$$

This means that it is supposed to be *impossible* to predict the outcome of an observation precisely, which violates the scientific principle that nature is orderly and predictable.

This so-called "principle", Eq.(11.89), is proposed merely to try to justify the claim that a particle can have no phase and that the geometrical optics approximation for quantum particles is valid. In particular, the phase difference $\Delta\phi$ between two interfering component waves with a path difference $\Delta r$ and propagation constant k is given by

$$\Delta\phi = k\Delta r. \tag{11.90}$$

If the phase difference $\Delta\phi$ is random due to a random spread in the propagation constant (due to a "line width"), and if the spread in the phase difference is such that

$$\delta(\Delta\phi) = \Delta k \Delta r > 2\pi, \tag{11.91}$$

then clearly no interference can be observed. Since for a quantum particle $k = p/\hbar$; Eq.(11.91) is then Eq.(11.89) where $r = q$, as was to be demonstrated. Since particle interference *is* observed; the uncertainty principle, Eq.(11.90), must violate all empirical observations involving particle interference..

A number of trivial and obvious examples of how the Heisenberg "uncertainty principle" is experimentally violated by many orders

of magnitude are given by Wesley (1996m,o). The uncertainties required by Eq.(11.89) are just too huge to be anywhere close to reality. For example, a photon from a light source with a fractional line width $\Delta\lambda/\lambda < 10^{-6}$ has, thus, a momentum uncertainty that is given by $\Delta p/\hbar = |2\pi\Delta\lambda/\lambda^2| < 10^{-1}$ cm$^{-1}$ for $\lambda = 6\times 10^{-5}$ cm. It can give information about the interior of a living cell of size $\Delta q < 10^{-3}$ cm; so the simultaneous uncertainties in p and q for the photon while in the cell is such that

$$\Delta p\,\Delta q/h < 10^{-4} \quad , \tag{11.92}$$

a violation of the "uncertainty principle", Eq.(11.89), by four orders of magnitude.

There is no reason to consider any hypothetical "thought experiments" that are contrived to try to justify the "uncertainty principle". Ordinary actual laboratory observations readily reveal its empirical absurdity.

The "uncertainty principle", Eq.(11.89), also implies the absurd conclusion that the momentum and position of a quantum particle are functionally dependent upon each other; since the measurement of one is supposed to affect the measurement of the other. In real life the momentum and position of a quantum particle can be chosen quite independent of each other!

The orthodox claim that p and q must be measured simultaneously to *know* their simultaneous values at some instant is absurd. The earlier position of a quantum particle can be deduced *after* its momentum, and thus velocity, has been measured. Etc.

11.15e The orthodox "correspondence principle" is impossible – According to the orthodox "correspondence principle" quantum mechanics is supposed to predict microscopic behavior; while classical physics is supposed to predict macroscopic behavior. Thus, quantum mechanics is supposed to be compatible with classical physics. Orthodoxy, thus, claims that there is a "correspondence" between quantum mechanics and classical mechanics. *But this is not true*! Macroscopic observations involve quantum behavior that cannot be predicted by classical mechanics. The "correspondence principle" is impossible. For example, a quantum particle can be diverted by diffraction kilometers from its would-be classical trajectory.



Interference phenomena need not be limited to microscopic effects; the Michelson stellar interferometer involved slits meters apart. Macroscopic thermodynamic systems can be governed by quantum statistics and not the classical Boltzmann statistics. Etc.

Although it is necessary to introduce classical results, assuming no wave effects, into the wave equation in order to obtain quantum or wave behavior; the solution generated is not at all compatible with the classical case where no wave effects are assumed to be present. Classical physics may be regarded as representing *boundary conditions* that must be applied in order to obtain the wave solution; but these *boundary conditions* are independent of the resulting wave solution. But, of course, conversely the wave behavior is dependent upon the classical *boundary conditions*.

11.15f The orthodox "operator approach" fails completely – Orthodox quantum mechanics is cluttered with ad hoc presecriptions to yield appropriate $\Psi$ functions, eigenvalues, and spectral line wavelengths. Although the first step in any empirical science should be the summarization of the data in empirical formulas and rules; the range of validity of such empirical formulas and prescriptions are generally quite limited and fail when too generally interpreted.

Thus, according to the orthodox Copenhagen quantum mechanics *all* physics is supposed to be predictable by solving appropriate eigenfunction–eigenvalue problems. If $\hat{F}$ is an appropriate operator, the eigenfunction $\Psi$ and eigenvalues F are then given by the differential equation

$$\hat{F}\Psi = F\Psi, \tag{11.93}$$

subject to appropriate boundary conditions.

For bound systems the appropriate differential Eq.(11.93) yields a discrete set of eigenfunction $\Psi_n$ and eigenvalues $F_n$, characterized by integer quantum numbers n, where

$$\hat{F}\Psi_n = F_n\Psi_n \ . \tag{11.94}$$

Appropriate differential operators $\hat{F}$ are supposed to be given by replacing the momentum $\mathbf{p}$ by $-i\hbar\nabla$, and the position $\mathbf{r}$ by $\mathbf{r}$, thus,

$$\mathbf{p} \rightarrow -i\hbar\nabla \qquad \text{and} \qquad \mathbf{r} \rightarrow \mathbf{r}, \tag{11.95}$$

in any classical mechanical expression $F(\mathbf{p},\mathbf{r})$. Thus, for example, the Schroedinger Eq.(11.82) may be derived from the classical expression for the total energy, $p^2/2m + V = E$, which, upon making the replacements (11.95) yields the operator $\hat{F} = -(\hbar^2/2m)\nabla^2 + V(\mathbf{r})$. Operating on $\Psi$ this operator yields the energy eigenvalues E; thus,

$$\hat{F}\psi = \left[-(\hbar^2/2m)\nabla^2 + V(\mathbf{r})\right]\psi = E\psi\,, \tag{11.96}$$

which is the Schroedinger Eq.(11.82).

By trial and error it is immediately apparent that the scheme works only for 4 or 5 classical expressions. As a general approach it clearly fails. In addition, since $\mathbf{p}$ and $\mathbf{r}$ commute in classical expressions; only symmetric operators for the commutation of $-i\hbar\nabla$ and $\mathbf{r}$ are admissible. It may also be readily discovered that generalized coordinates will not work; so the scheme is limited to cartesian coordinates and cartesian components of the momentum to obtain operators. Moreover only Hermetian operators $\hat{F}$, where $\int\Psi^*\hat{F}\Psi = \int\Psi\hat{F}^*\Psi^*$, are supposed to be admissible. The "operator approach" has such a drastically limited validity that it is clearly worthless and hardly admissible as a fundamental law for *all* physics, as claimed by the orthodox Cophenhagen quantum mechanics.

Even when all of the restrictions, mentioned above, are satisfied it still does not work: One of the simplest of all classical mechanical expressions is

$$\mathbf{p} - \nabla W(\mathbf{r}) = 0, \tag{11.97}$$

where $W(\mathbf{r})$ is Hamilton's characteristic function, which is a function of position only. Making the operator replacements, Eqs.(11.95), yields

$$\left[-i\hbar\nabla - \nabla W(\mathbf{r})\right]\psi = b\psi\,, \tag{11.98}$$

where $b$ is an eigenvalue, that may be zero. The solution to this differential Eq.(11.98) is given immediately by

$$\psi = \exp\left[i(W(\mathbf{r}) - b\cdot\mathbf{r})/\hbar\right].$$

If the classical motion is cyclic, as may be prescribed by $W(\mathbf{r})$, then the $\psi$ function to be single valued yields the old Sommerfeld quantizing condition

$$\oint p_i dq_i = \oint W(q_i)dq_i = 2\pi n\hbar, \tag{11.99}$$



where i is not summed and n is an integer. But this is not an admissible orthodox Copenhagen quantum mechanical result!

According to the orthodox Copenhagen quantum mechanics, the classical total energy E is to be replaced by the time operator,

$$E \rightarrow i\hbar\,\partial/\partial t\,, \tag{11.100}$$

which makes no sense; because it is simply a *tautology*. The *only* time variation permitted is given by the factor shown in Eq.(11.86); so

$$\hat{E}\Psi = i\hbar\partial\Psi/\partial t = E\Psi; \tag{11.101}$$

and nothing new is achieved. The orthodox theory is, in fact, time independent!

11.15g "Expectation values" cannot be observables – The orthodox Copenhagen quantum mechanics, that is based upon the "operator approach" or the eigenfunction-eigenvalue problem, Eq.(11.93), claims the quantities, the *observables*, that can be measured in the laboratory are given by or *defined* by "expectation values":

$$\langle F\rangle = \int\Psi^*\hat{F}\Psi = \int\Psi^* F\Psi\,. \tag{11.102}$$

For constant eigenvalues, such as the total energy E, Eq.(11.102) yields

$$\langle E\rangle = \int\Psi^* E\Psi = E\int\Psi^*\Psi. \tag{11.103}$$

It is thus only necessary to choose normalized eigenfunctions $\Psi$, such that

$$\int\Psi^*\Psi = 1, \tag{11.104}$$

to obtain agreement with classical physics in this case.

In general, according to the orthodox theory, the "expectation value" is supposed to be only the most likely observation of many intrinsically possible. It is supposed to be a weighted statistical average over all of the intrinsic possibilities. Since the $\Psi$ function is defined throughout all space; the "expectation value" is then presumably a weighted integral average over the state of the whole universe. But *science* cannot be involved with intrinsic probabilities nor with such "nonlocality".

It is supposed to be demonstrated in textbooks presenting the orthodox theory that "expectation values" recover classical mechanical

motion, thereby supposedly proving the "correspondence principle". However, only a redundancy, or tautology, is involved; since the demonstration depends upon the arbitrary replacement of operators, Eqs.(11.95), in the classical mechanical expression and then the arbitrarily chosen definition for "expectation values". There is, of course, no physical "correspondence" between the predictions of classical mechanics and the wave behavior of particles.

11.15h Schroedinger's time dependent equation is wrong - For a slow particle Schroedinger (1926) proposed his "time dependent equation":

$$(\hbar^2/2m)\nabla^2\Psi - V(r)\Psi = -i\hbar\,\partial\Psi/\partial t, \qquad (11.105)$$

which yields the valid time *independent* Eq.(11.82) for the complex time variation Eq.(11.86), which must be always assumed for the orthodox theory. This expression (11.105) is scientifically unacceptable; because it contains the imaginary number $i = \sqrt{-1}$ without any prescription of how the i is to be eliminated to obtain a pure real expression as some linear combination of the real part and the imaginary part, that can then be measured in the laboratory.

The complex exponential de Broglie wave, Eq.(11.44), for a free particle satisfies this "time dependent equation" (11.105); but, as explained in Sections 11.7b and 11.15b, no explicit phase being specifiable, it predicts no interference phenomena involving rigid boundaries.

A "wave packet" that spreads outward with time can be obtained as a solution to the "time dependent" Eq.(11.105) (Schiff 1949); but such a "wave packet" is physically impossible, as discussed in the following Section 11.15i.

11.15i A particle "wave packet" cannot exist - A group wave, or "wave packet" (Wesley 1983r) arises when component waves differing slightly in frequency are combined. Such a group wave can arise in a dispersive medium, where the propagation constant k is a function of the frequency $\omega$, which gives rise to a group velocity (Stratton 1941) given by

$$u_g = 1/(dk/d\omega). \qquad (11.106)$$



For particles the component waves of the group must each have about the same de Broglie wavelength $\lambda = 2\pi\hbar/|p|$. The size of a group, or "wave packet", must equal many such wavelengths. Since quantum particles, such as photons, can be readily localized within a de Broglie wavelength; a localized particle cannot be represented as a huge "wave packet".

If, as the orthodox theory claims, the huge "wave packet" "collapses" instantaneoulsy into a localized particle upon observation, then impossible infinite velocities are necessary to "collapse" the extended "wave packet" into essentially a point. Since no such infinite velocities can occur; and no such "collapse" is possible; no such "wave packet" can exist in the first place.

Needless to say, the fictitious impossible "wave packet" has never been observed - only the localized "collapsed" particles are ever observed. With no empirical evidence for their existence scientifically "wave packets" cannot exist.

A group wave, or "wave packet", can only arise in a dispersive medium. In empty space, where a particle wave exists, all wave velocities become identical; so no "wave packet" can exist.

Since a "wave packet" is composed of component waves of different frequencies and wavelengths; a particle with a unique energy and momentum cannot be represented by a "wave packet".

If photons were "wave packets" spreading out in time, then the spread should be great enough to obliterate the millisecond pulses observed from pulsars after travelling light-years through space.

11.15j The Lagrangian-Hamiltonian method leads to errors -The Lagrangian method in classical mechanics is not a valid representation of Newtonian mechanics. It "begs the question": an integral of the motion, as an integral of Newton's second law, an energy integral, a partial solution to the problem, is assumed to be known even before the problem can be stated. In particular, the Lagrangian $L$ is assumed to be given initially for a conservative system, where

$$L = T(q_i, \dot{q}_i) - V(q_i), \qquad (11.107)$$

where T is the kinetic energy expressed in generalized coordinates $q_i$ and time derivatives $\dot{q}_i$ and V is the potential energy expressed in terms of the generalized coordinates $q_i$. Newton's second law

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is then supposed to be given by

$$(d/dt)(\partial L/\partial \dot{q}_i) - \partial L/\partial q_i = 0; \qquad (11.108)$$

but this is not strictly true; since T and V in Eq.(11.107) are already integrals of Newton's second law.

By *analogy* with Newton's second law, the "canonical momentum" is *defined* as

$$p_i = \partial L/\partial \dot{q}_i, \qquad (11.109)$$

which is, of course, in general not the *physical momentum*. The confusion between a mathematical function simply arbitrarily labelled "momentum", which is devoid of any direct physical meaning, and an actual *physical momentum* has led to frequent error - especially in orthodox quantum mechanics. It is supposed to be the "canonical momentum" and not the real momentum that is to be replaced by the operator $-i\hbar\nabla$.

The insufficient Maxwell field theory can be written by *analogy* with the Lagrangian method for mechanics by defining an arbitrary Lagrangian as

$$L = T - q\Phi + q\mathbb{A}\cdot\mathbb{v},$$

where T is the kinetic energy and $\mathbb{v}$ the velocity of the charge q, $\Phi$ is the electrostatic potential of a source and $\mathbb{A}$ is the magnetic vector potential of a source (Goldstein 1950). The result is, of course, merely another mathematical representation of the Maxwell equations, that is as wrong as the ordinary representation.

Perhaps the worst error involving the Lagrangian method is the introduction of an arbitrary Lagrangian to yield *by analogy* Schroedinger's time dependent equation (11.105). With the "canonical variables" so defined in terms of the $\Psi$ field, an *analogous* simple harmonic oscillator problem may be solved to yield "second quantization" or "quantum field theory" - a total absurdity!

Almost never is the Lagrangian method applied to yield correct physical results. One should turn to the more basic fundamental generally valid Newton's second law to obtain correct scientific physical results!

11.15k Probability amplitudes are scientifically unacceptable - The idea that nature is not precisely predictable and that only uncertain intrinsic probabilities or expectations are possible is contrary to the scientific principle that nature is orderly and that in principle precise prediction is always possible.



There is no empirical evidence that any such intrinsic probabilities or uncertainties actually exist in nature. On-the-contrary. the orthodox "uncertainty principle" involves presumed unavoidable uncertainies that are many orders of magnitude greater than the actual experimental errors (Section 11.15d).

In situations where actual distributions are observed there are always unknown random initial conditions involved: and it is never necessary to assume that nature herself introduces unavoidable intrinsic uncertainties. If quantum theory manages to predict some observed distributions, it does not warrant the orthodox claim that the distributions involve intrinsic probabilities. To add the word "probability" to observed distributions contributes nothing to the evidence. Thus, if $\Psi\Psi^*$ happens to represent an actual observed particle density distribution (normalized to unity within the appropriate volume), it alters nothing by calling it a "probability density". In particular, it is a matter of indifference if the generating $\Psi$ function is called a "probabiltiy amplitude" or simply "the wave function" or else "the $\Psi$ function". Since nature can have no intrinsic probabilities according to science; the word "probability" applied to the particle density or to the $\Psi$ function itself is not warranted.

11.15l "Matrix mechanics" may be ignored - "Marix mechanics" (Heisenberg 1924, 1926) was a cumbersome ambiguous semi-empirical scheme for generating eigenvalues, that was limited to a few examples, such as the simple harmonic oscillator. Schroedinger in his second 1926 paper was able to show that the limited success of "matrix mechanics" was merely a consequence of his own more general theory. Having no general significance, "matrix mechanics" may be ignored.

11.15m Single particle waves are impossible - According to the orthodox Copenhagen quantum mechanics a *single* particle is supposed to exhibit wave behavior. The $\Psi$ wave function is supposed to represent a *single* particle. A particle, that is always observed

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only at some highly localized region in space, or point, is supposed to be somehow simultaneously smeared out over all space.

A *single* particle, such as a photon or an electron, is supposed to pass through two widely separated slits simultaneously to then *interfere with itself*. It should not be thought that such orthodox nonsense is justified; because only microscopic phenomena are involved. The Michelson stellar interferometer operates successfully with slits up to 15 meters apart, which would then require photons from stars to be smeared out laterally over a 15 meter region, according to the orthodox theory.

Because a photon or electron is only observed at a point, or highly localized region; the orthodox theory claims that the act of observation causes the quantum particle, that is actually smeared out over all space, to *collapse* instantaneously with infinite velocities onto the point where it is observed. The orthodox Copenhagen quantum mechanics also claims that a quantum particle is not localized, but is a "wave packet" smeared out over all space (Section 11.15h). The presumed fact that a quantum particle is actually smeared out over all space can never be verified experimentally; because the very act of observation makes the smeared-out quantum particle suddenly appear as an ordinary everyday *point* particle - like leprechauns, that turn into ordinary everday objects when one tries to observe them.

When a flux of photons is suffciently reduced, wave behavior disappears, according to the adequate carefully performed experiments of Dontsov and Bas (1967) and Panarella (1982, 1987). Such low intensity experiments have been reviewed by Wesley (1996j). The orthodox claim of single particle interference has, thus, been proven to be experimentally false - as well as impossible in principle.

For *the* hydrogen atom one speaks of *the* electron moving in the field of *the* proton subject to a "wave requirement" specified by the Schroedinger time independent Eq.(11.82). This can mean that the *single* electron, that when together with other electrons is subject to a force producing wave behavior, is also subject to such a wave-producing force when interacting with a *single* proton. Or else it can mean that the system being treated is in fact not a *single* hydrogen atom, but instead is a system consisting of many hydrogen atoms



coherently or synchronously coupled together by their mutual electrodynamic wave fields (radiated and absorbed). Ordinary hydrogen light sources, yielding the spectral lines that provide the evidence for *the* hydrogen atom, contain an order of about $10^{19}$ hydrogen atoms per cubic centimeter.

The fact that the electron oscillates back and forth along a discrete orbital trajectory, according to the scientific quantum theory for the hydrogen atom (Wesley 1983q), apparently violating the conservation of angular momentum, seems to indicate such a mutual coupling among many excited hydrogen atoms (but not necessarily for the ground state). Or perhaps it is evidence for the existence of a third particle in the excited hydrogen atom, namely a photon.

11.15n Orthodox pseudo-measurement theory - The orthodox Copenhagen quantum mechanics in attempts to justify some of its absurdities has resorted to pseudo-measurement ideas. According to Bohr, for example, it makes no sense to ask through which of two slits a particle may have passed to form an interference pattern; because the particle does not even exist before it is observed during a *measurement*.

Heisenberg (1927) in an attempt to justify his empirically invalid "uncertainty principle" (Section 11.15d) claimed that in order for two canonically conjugate variables p and q to thus exist at the same time they had to be *measured simultaneously*. And instead of appealing to actual experiments, he felt that contrived *thought experiments*, involving *thought measurements*, were sufficient to prove the truth of his "uncertainty principle". Ordinary actual *scientific* measurements made at an *earlier* time can provide valid evidence for the current state of a system. The very existence of a state cannot be denied merely because it is not *now* being measured. Nor can the precise state of a system be denied; because of improper measurement procedure, such as requiring the measurement of canonicllly conjugate variables be made simultaneously.

Since precise measurements are supposed to be impossible; the precise state of a system must also remain unknown, according to the orthodox Copenhagen theory. A system is, thus, only supposed to exist in some uncertain probabilistic state.

Einstein, Rosen, and Podolsky (1935) were able to demonstrate, using the orthodox pseudo-measurement theory itself (where the superposition of wave functions is erroneously interpreted as implying physical causality, as discussed in Sections 11.2b and 11.3), that the *precise state* of a system can in principle be *known*! Thus, the orthodox claim that only probabilistic or uncertain states of *reality* are possible is false. This proof is inappropriately referred to as a *paradox*, the "EPR paradox", by the believers in the orthodox theory, the word "paradox" being used to imply that the EPR proof is faulty.

11.15o The orthodox claim of "nonlocality" - Bohr introduced the mystical idea of "nonlocality" in an attempt to discredit the EPR proof against the orthodox theory. A precise state of a system II is not supposed to be knowable; because Bohr claimed that it always remains coupled to the initial combined system I involving the measuring apparatus with its claimed uncertainties. The coupling is supposed to remain no matter how widely separated system II becomes from the initial system I that includes the measuring apparatus. Consequently, if the measuring apparatus is changed long after a particle has left the apparatus, it is supposed to produce an instantaneous effect upon the particle no matter how wide the separation. Like astrology, the orthodox Copenhagen idea of "nonlocality" permits instantaneous effects produced by distant causes without any physical mechanism being required.

This orthodox idea of "nonlocality" is compatible with the idea that "expectation values" can yield physical observables (Section 11.15f). In particular, an "expectation value" $\langle b \rangle$ is defined by

$$\langle b \rangle = \int \Psi^* \hat{b} \Psi \ , \qquad (11.110)$$

where $\hat{b}$ is the appropriate operator and the integral is taken over all space. Thus, the "expectation value" is a function of the state of the rest of the universe represented by the $\Psi$ function defined throughout all space. Since the exponential time variation, $\exp(-iEt/\hbar)$ cancels out in Eq.(11.110); whatever the *cause* might be anywhere in the universe that determines $\Psi$ and, thus, the *effect*, the "expectation value", it acts *instantaneously!*



11.15p "Bell's inequality" to test orthodox "nonlocality" - If Bell's (1965, 1966) inequality is satisfied, then Bohr's idea of "nonlocality" is supposed to be true. But if the inequality is not satisfied, then classical locality is supposed to be valid. The inequality is supposed to provide an experimental test for or against "nonlocality".

Experiments have been performed, such as those by Aspect et al (1981, 1982), who claims to, thus, confirm orthodox "nonlocality". Unfortunately, the claims are obviously fraudulent; because it is assumed that a *single* photon incident upon a photomultiplier was always detected with 100% certainty; whereas, at best, only about one in two hundred photons could be detected. The experimental evidence and the false claims have been carefully reviewed by Wesley (1996o).

11.15q The "hidden variable" ploy - Since the orthodox Copenhagen quantum mechanics makes the claim that only uncertain probabilistic values of physical quantities can ever be known; it is claimed that additional information supplied by "hidden variables" would have to be known in order to obtain precise knowledge of physical quantities. Since the scientific quantum theory presented here shows that precise values of physical quantitites can be known from the evidence normally available; no "hidden variables" are necessary!

von Neumann (1955) wrote his famous theorem to try to prove that, the orthodox Copenhagen quantum mechanics is correct, because "hidden variables" cannot exist. However, his premise contained the conclusion: Obviously the orthodox quantum mechanics could not be correct, if "hidden variables" existed. The existence or nonexistence of hidden variables is, in any case, irrelevant; since the orthodox quantum mechanics is proven wrong from the existing evidence; no further evidence supplied by "hidden variables" is required.

## 11.16 Quantum Theories of Bohm and de Broglie

Madelung (1926), de Broglie (1927), and Bohm (1952, 1953) proposed the idea that particles could follow discrete trajectories given by integrating the velocity v given by the "guidance formula"

$$w = - (i\hbar/m) \nabla ln \Psi \ , \qquad (11.111)$$

which is clearly satisfied by the de Broglie wave, Eq.(11.44) where $p = mw$. Thus, no uncertainties nor intrinsic probabilities need be assumed in this case.

Unfortunately, this is simply an alternative mathematical representation of the original quantum particle velocity $w$ deriveable from Schroedinger's arbitrarily chosen flux $\mathbb{G}$ and density $P$, Eqs.(11.88), that yield

$$\begin{aligned} w = \mathbb{G}/P &= - (i\hbar/2m)( \nabla\Psi/\Psi - \nabla\Psi^*/\Psi^*) \\ &= - (i\hbar/m) \nabla ln \Psi . \end{aligned} \qquad (11.112)$$

This means that, if $\Psi$ is interpreted (improperly) as a "probability amplitude", then $w$, as given by the "guidance formula" (11.111), can be interpreted to merely mean the velocity of a "probability flux", which need not be the velocity of a particle itself. A trajectory obtained by integrating $w$, Eq.(11.111), may then be interpreted as a "probability trajectory", that need not be the *discrete* trajectory of a quantum particle itself.

According to the scientific quantum theory presented here, the velocity defined by Eq.(11.111) or (11.112) is, at best, comparable only to the approximate time average quantum particle velocity defined by Eqs.(11.20) and (11.23). Thus, an element of partial *reality*, devoid of any pseudo-probabilistic notions, is contained in the "guidance formula" (11.111).

Bohm (1991) abandoned his earlier 1952 idea of a "causal quantum theory" to end up with a hearty endorsement of the orthodox Copenhagen quantum mechanics, as indicated in his 1993 book with Hiley (Bohm and Hiley 1993) entitled *The Undivided Universe*. The title of the book is chosen to represent his enthusiasm for Bohr's mystical idea of "nonlocality" or a "united universe".

de Broglie (1953, 1960) published many papers and books on his idea that quantum particles are accompanied by a "pilot wave", that then requires a "double solution". Although, unlike Bohm, de Broglie never abandoned the belief that quantum phenomena should be handled in terms of a scientific quantum theory (not offered by the orthodox Copenhagen mysticism); he was never able to resolve the wave-particle



problem (as done here in Section 11.4). His "double solution" idea never bore fruit.

Since the wave behavior exhibited by a flux of particles requires action-at-a-distance to couple the quantum particles together coherently; a "pilot wave" in a certain sense must accompany the particles. But this "pilot wave" cannot be a separate physical entity; since only the particles themselves can carry the momentum and energy.

The proposal of independent "empty waves" to account for wave behavior must be rejected; since causes that produce irreversible effects must carry energy and momentum to produce these effects; so nothing causal can be ascribed to an "empty wave". Only the quantum particles themselves, carrying the required energy and momentum, can be the cause of the observed wave effects.

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